JUNE, 1949

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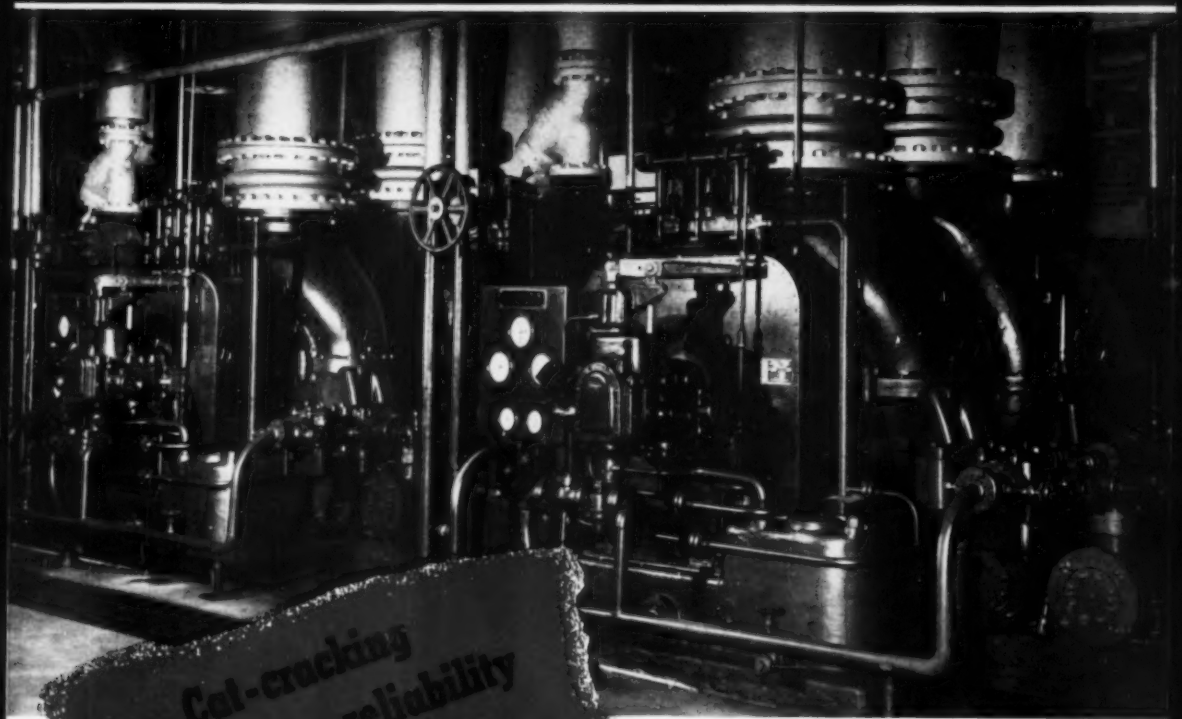

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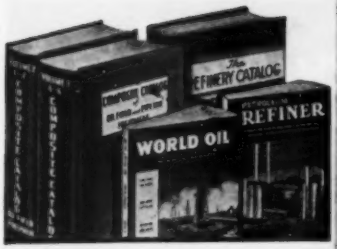

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VOLUME 28, NO. 6 June, 1949

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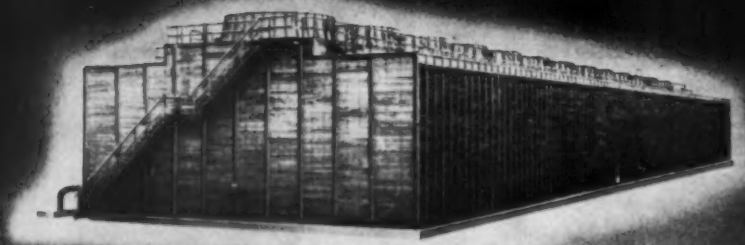
Specify MARLEY Double-Flow



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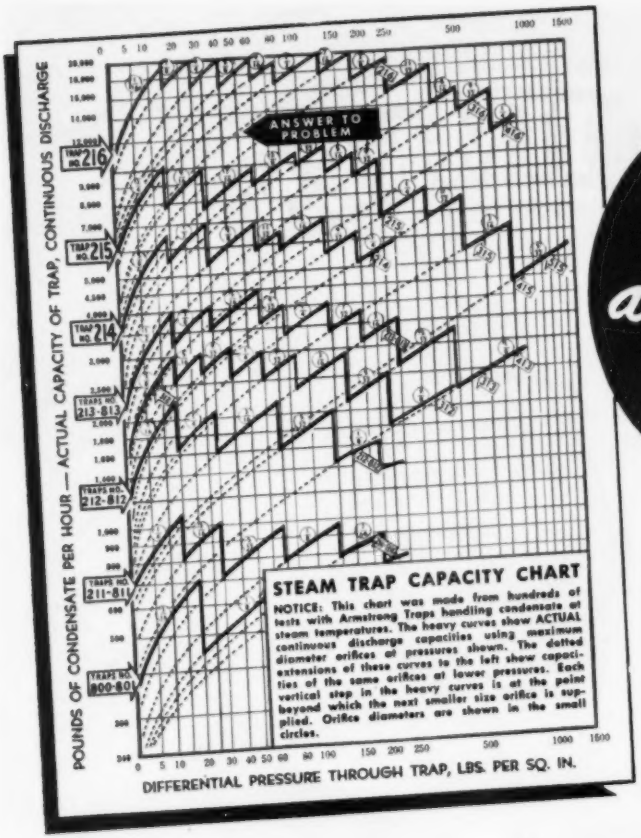
POUNDS OF CONDENSATE PER HOUR — ACTUAL CAPACITY OF TRAP, CONTINUOUS DISCHARGE
DIFFERENTIAL PRESSURE THROUGH TRAP, LBS. PER SQ. IN.
ANSWER TO PROBLEM
TRAP NO. 216
TRAP NO. 215
TRAP NO. 214
TRAPS NO. 213-813
TRAPS NO. 212-812
TRAPS NO. 211-811
TRAPS NO. 900-801
STEAM TRAP CAPACITY CHART
NOTICE: This chart was made from hundreds of tests with Armstrong Traps handling condensate at steam temperatures. The heavy curves show ACTUAL continuous discharge capacities using maximum diameter orifices at pressures shown. The dotted extensions of these curves to the left show capacities of the same orifices at lower pressures. Each vertical step in the heavy curves is at the point beyond which the next smaller size orifice is supplied. Orifice diameters are shown in the small circles.

BECAUSE good trapping starts with selection of the right trap for the job, Armstrong has provided all the data necessary for correct trap selection in the Armstrong Steam Trap Book. The Capacity Chart reproduced here is taken from this handy reference work. By means of this chart, any engineer can select the correct traps for his requirements. Here is a typical problem showing how the chart is used:

Given: An evaporator condensing 6000 lbs/hr at 50 psi when the steam is first turned on, but condensing only 1000 lbs/hr at 150 psi at the end of the process. Safety factor of 2 to 1 required at the *minimum* pressure differential.

Solution: Referring to the chart, the No. 216 Armstrong Trap with 7/16″ orifice for 150 psi pressure has a capacity of 12,000 lbs/hr at 50 psi. This provides for the 2 to 1 safety factor and is, therefore, the correct trap for the job.

The Armstrong Steam Trap Book provides recommended safety factors for different services and handy tables to help you calculate condensing rates. Other useful data included are: hook-up diagrams; do's and don't's; trouble-shooting tips; prices and specifications. You're welcome to a copy. **ARMSTRONG MACHINE WORKS, 852 Maple Street, Three Rivers, Michigan.**

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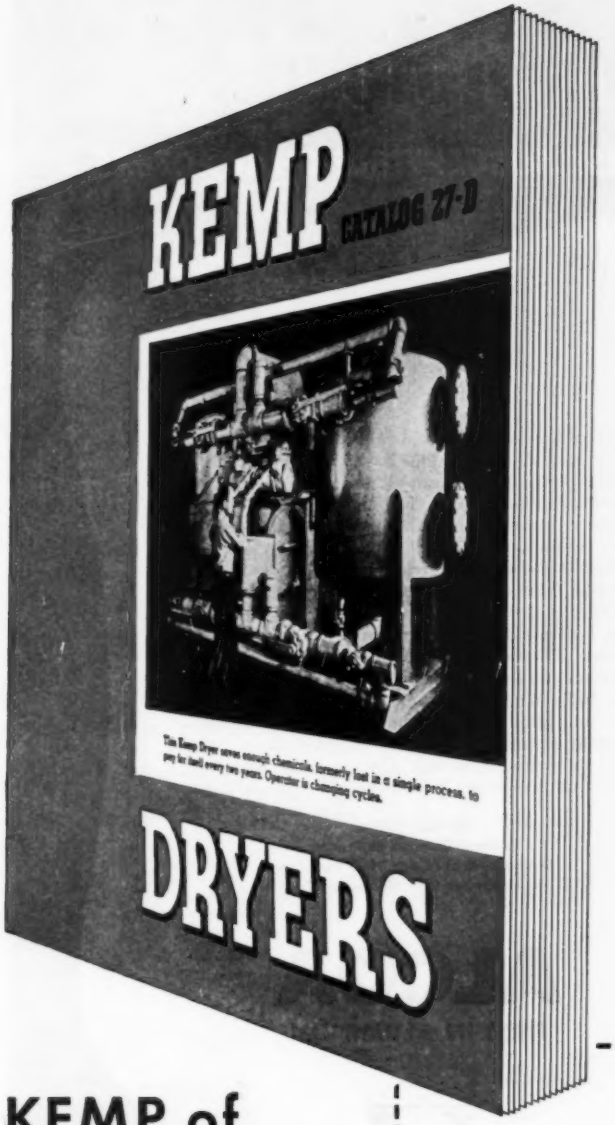
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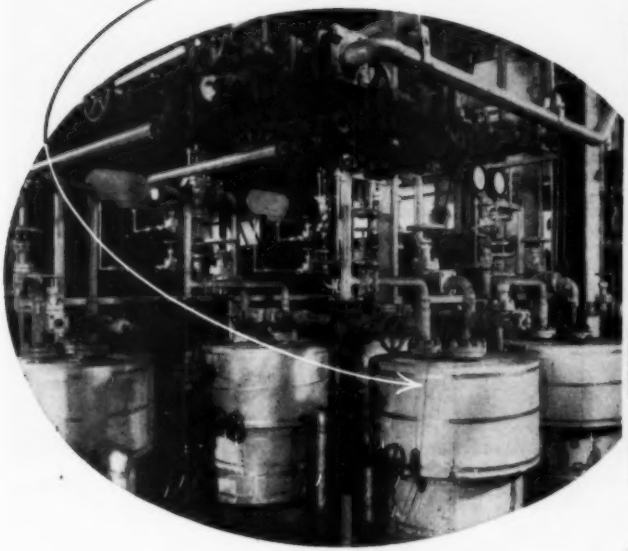

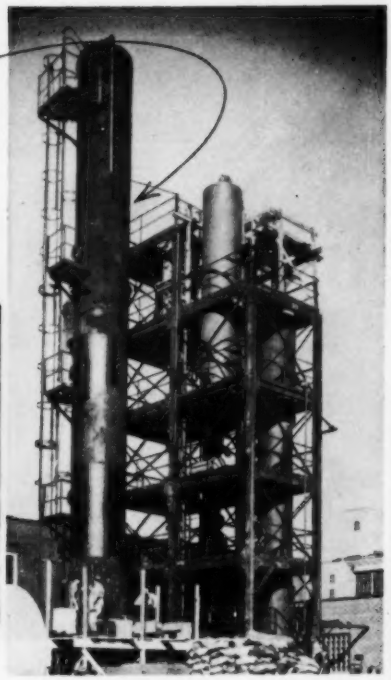

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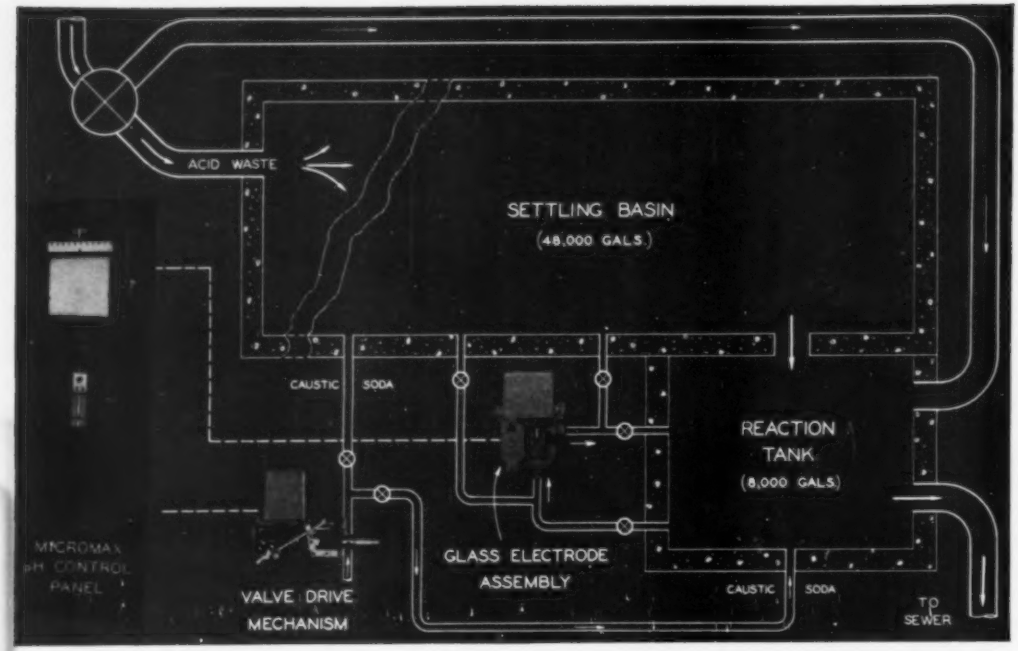

Schematic plan diagram of Micromax Automatic pH Control as applied to acid waste in Western Electric Co.'s new "controlled conditions" plant at Allentown, Pa. Waste is from metal-finishing and -plating operations.

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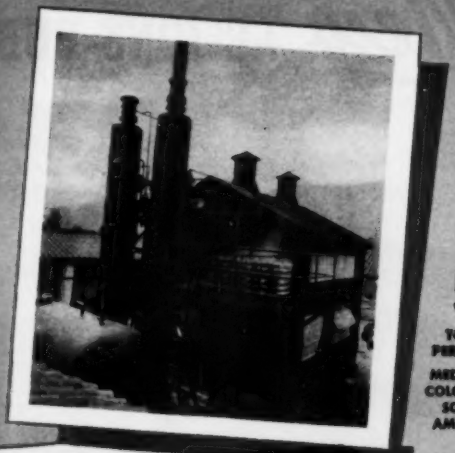

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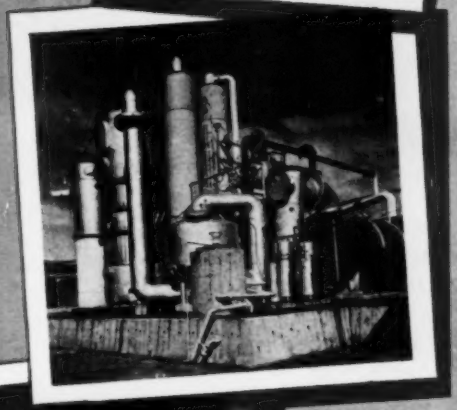

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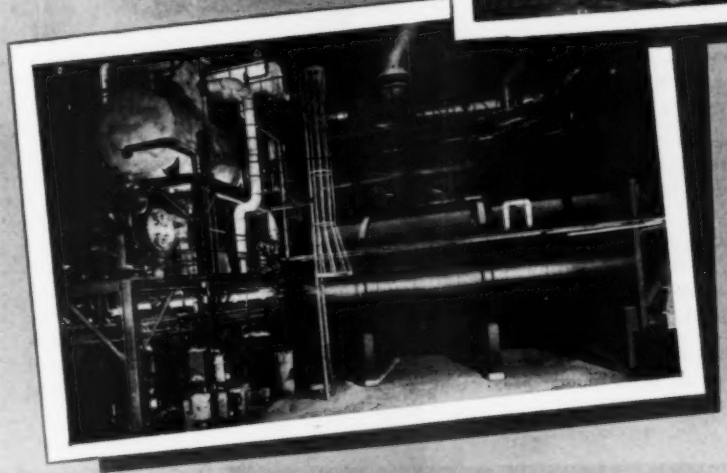

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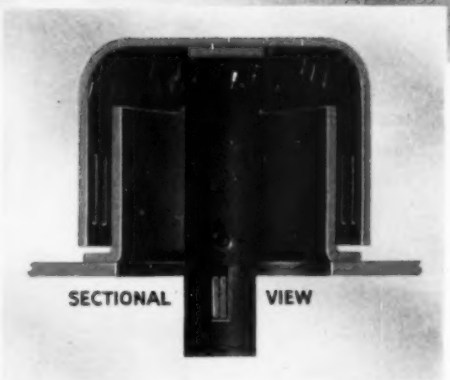

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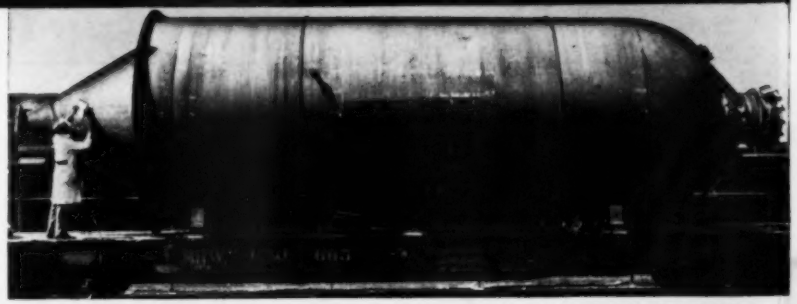

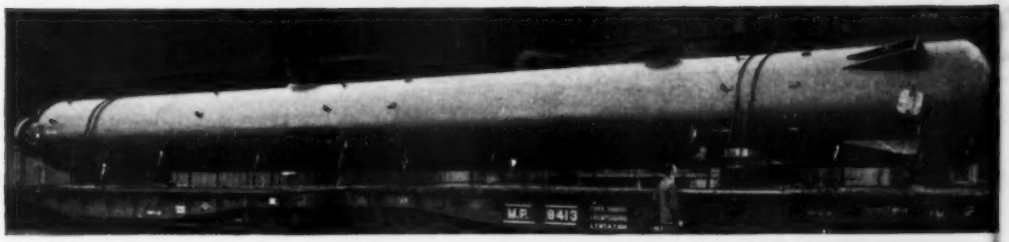

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FIELD ASSEMBLY OF PRESSURE VESSELS—Bulletin V-44.

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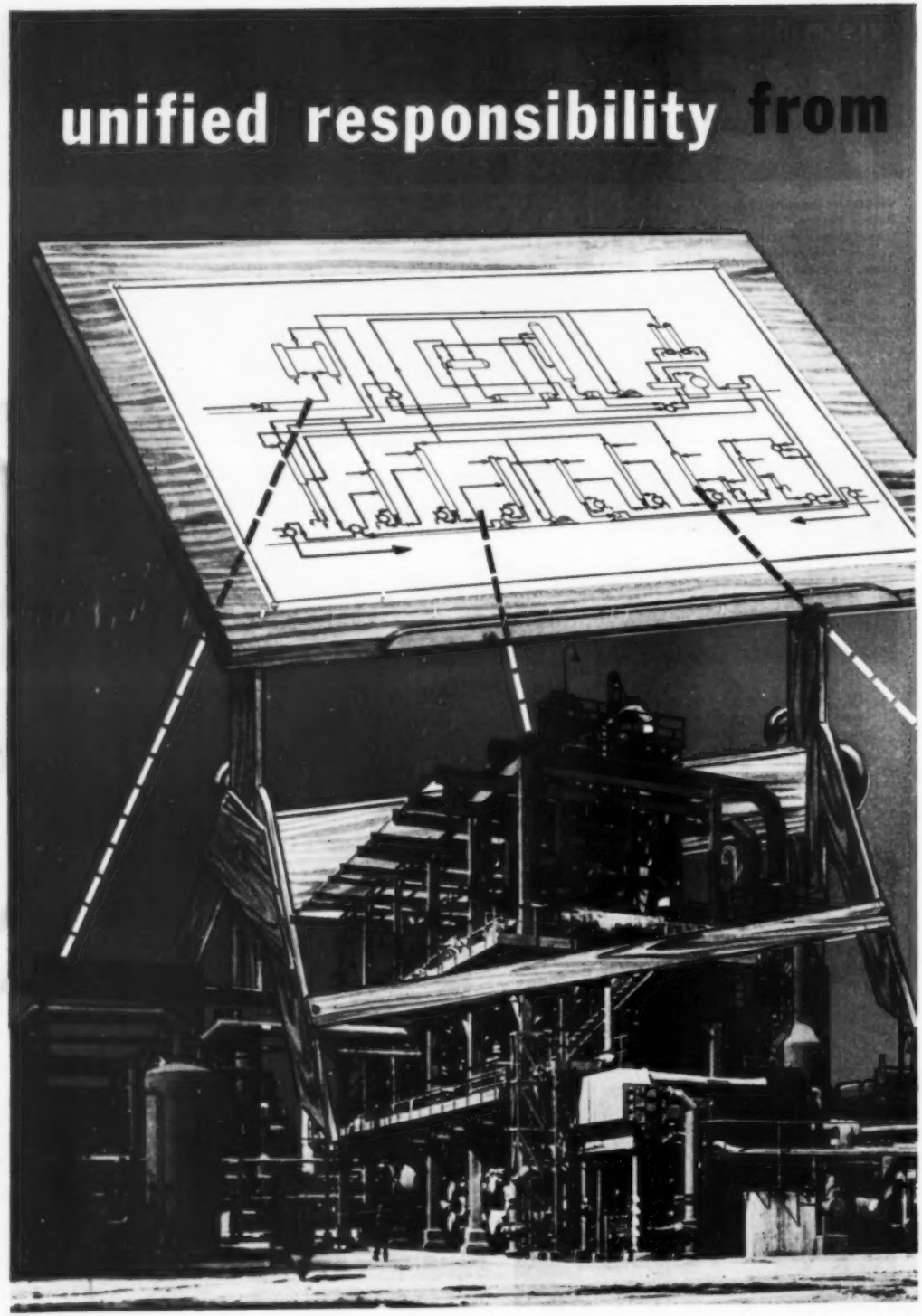
SMITHway VESSELS — Alloy, Alloy-lined, Clad, and Glass-lined —Bulletin V-46.

unified responsibility from

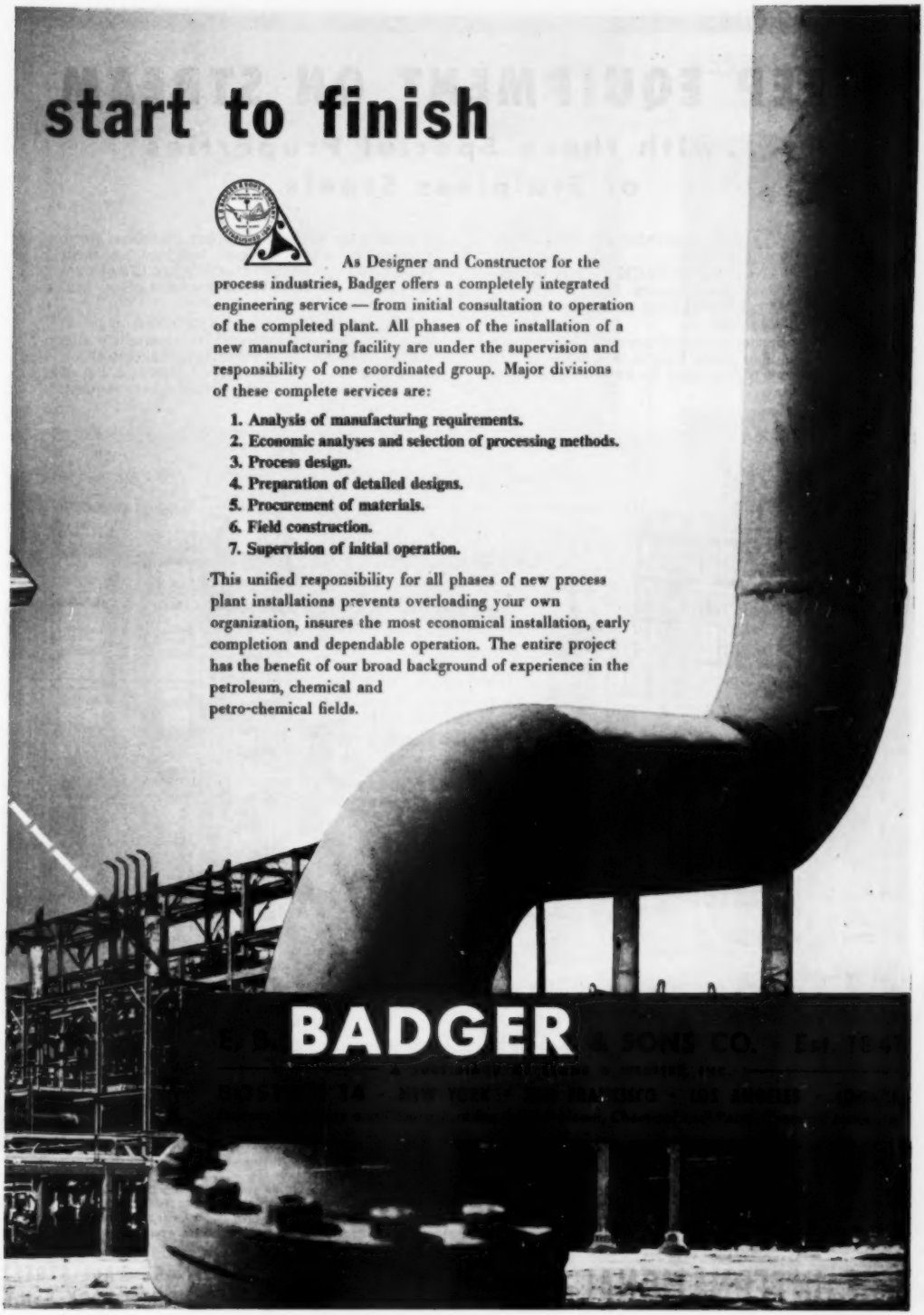


start to finish

As Designer and Constructor for the process industries, Badger offers a completely integrated engineering service — from initial consultation to operation of the completed plant. All phases of the installation of a new manufacturing facility are under the supervision and responsibility of one coordinated group. Major divisions of these complete services are:

1. Analysis of manufacturing requirements.
2. Economic analyses and selection of processing methods.
3. Process design.
4. Preparation of detailed designs.
5. Procurement of materials.
6. Field construction.
7. Supervision of initial operation.

This unified responsibility for all phases of new process plant installations prevents overloading your own organization, insures the most economical installation, early completion and dependable operation. The entire project has the benefit of our broad background of experience in the petroleum, chemical and petro-chemical fields.



KEEP EQUIPMENT ON STREAM

. . . with these Special Properties of Stainless Steels

STRENGTH . . . *at temperatures that would destroy ordinary metals* . . .

RESISTANCE TO ATTACK . . . from organic and mineral corrosive agents . . .

HIGH IMPACT VALUES to temperatures as low as −320° F.

These characteristics of austenitic chromium-nickel stainless steels help to save labor as well as time, and reduce costs by keeping equipment on stream.

Austenitic chromium-nickel stainless steels provide one of the strongest, toughest, and most economical means for extending the life of bubble towers, reactors, vapor lines and other vital equipment.

Investigate all the benefits stainless steels can give you. Leading steel companies produce austenitic stainless steels containing nickel in sheet, strip and all other commercial forms. A list of sources of supply will be furnished on request.

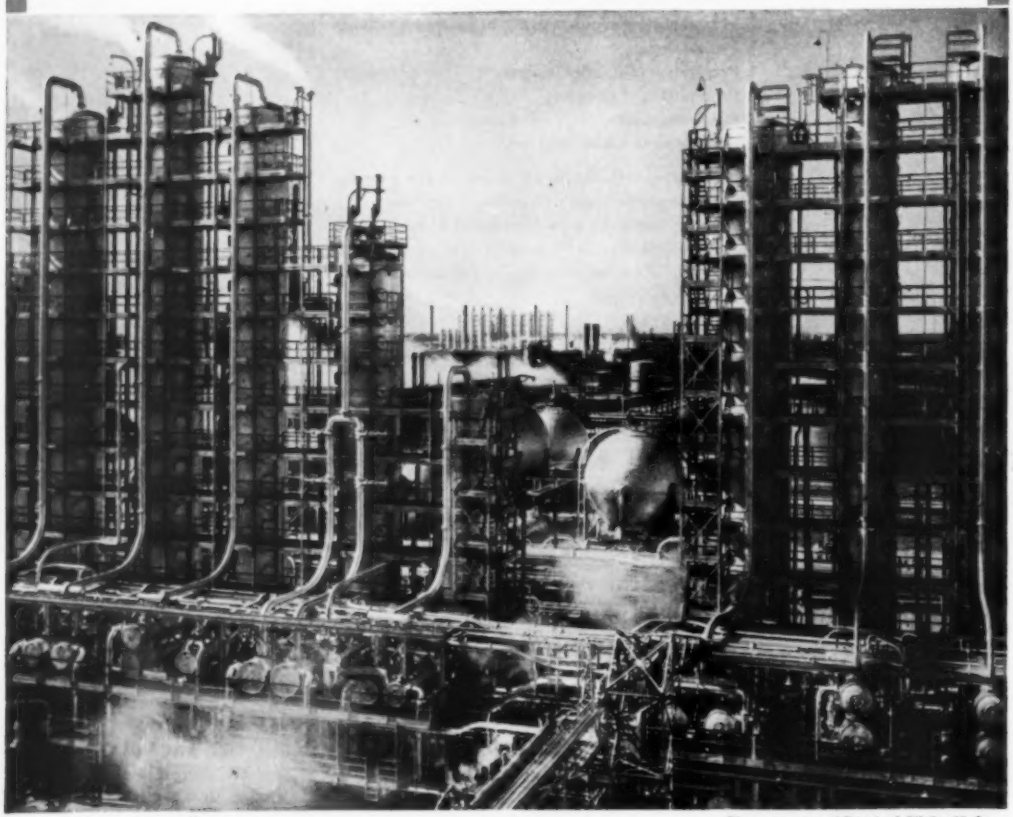
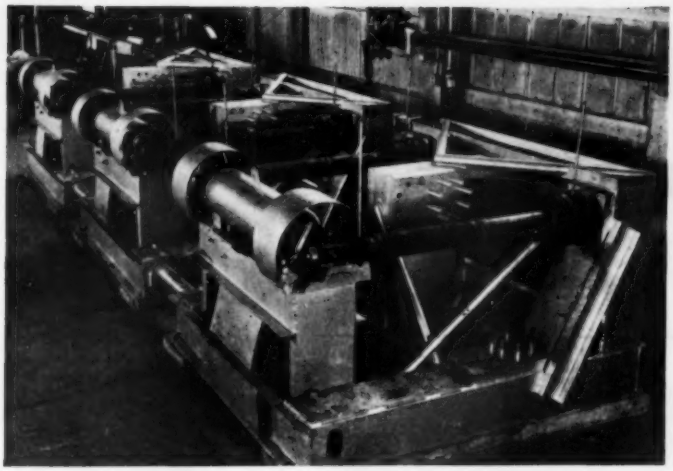


Photo courtesy of Standard Oil Co. (N. J.)

EMBLEM OF INCO SERVICE
TRADE MARK

Over the years, International Nickel has accumulated a fund of useful information on the properties, treatment, fabrication and performance of engineering alloy steels, stainless steels, cast irons, brasses, bronzes, nickel silver, cupro-nickel and other alloys containing nickel. This information is yours for the asking. Write for "List A" of available publications.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.



Strength through Design in Tube-Turn welding flanges

Taking the measure of piping fatigue

PIPE lines are *live, dynamic* members of a piping system. They *breathe* with changes in temperature and pressure. And the danger of fatigue failure from pressure shock, thermal shock, and cyclic conditions is ever-present.

More precise information was needed on this subject. So, Tube Turns research engineers set out to get the answers. For the purpose, they designed and built a unique cyclic testing machine to handle full-size piping assemblies under a wide range of temperature, pressure, and corrosive conditions. And on this torture rack they subjected flanged assemblies to reverse bending tests carried on to ultimate failure. Information revealed forms the basis of new designs for greater strength in Tube-Turn welding flanges.

Other piping assemblies, too—welding elbows, mitre bends, manufactured and fabricated tees, pipe bends—have been subjected to punishment more severe than any they would probably face in normal service.

And this perpetual search for greater strength through better design has paid off in the form of realistic, non-theoretical facts providing a sound basis for Tube Turns' manufacturing policies—facts important to anyone interested in getting his money's worth in long life from piping installations.

Tube Turns' research and development organization, finest in the welding fittings industry, is constantly striving for the improvement of present products, the development of new ones. Notable among their recent achievements have been the design of a new type welding tee and the development of aluminum welding flanges.

Ask to be put on the mailing list for Tube Turns' technical periodical, *Piping Engineering*. Paper 6.01, for instance, deals extensively with standard steel flanges. Others give you research findings and additional working information pertaining to piping not generally available in convenient form.

TUBE-TURN
tt
WELDING FITTINGS AND FLANGES

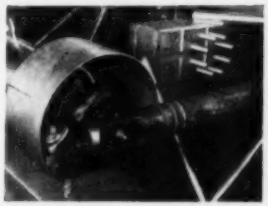
TUBE TURNS, INC.

244 East Broadway, Dept. H, Louisville 1, Kentucky

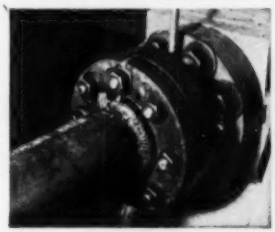
District Offices at New York, Philadelphia, Pittsburgh, Chicago, Houston, Tulsa, San Francisco, Los Angeles

TYPICAL FLANGE ASSEMBLY TESTS

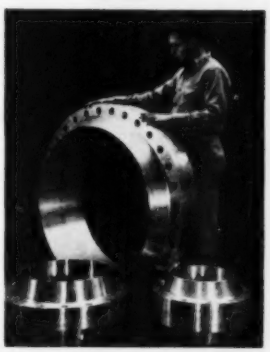
Assemblies were of 4-inch nominal size with 300 pound forged steel flanges and standard weight pipe.



Eccentric crank arm produces up-and-down movement which creates a cyclic bending moment on flange or fitting at opposite end of assembly.

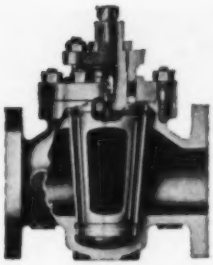


Water spurts from crack in test specimen. Almost invariably, failure occurred in the pipe adjacent to the flange.

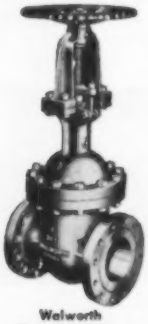


Aluminum welding flanges . . . another Tube Turns first! Available in a wide range of types and sizes.

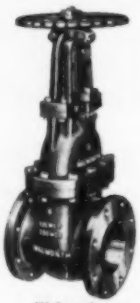
• VALVES
• PIPE FITTINGS



Walworth
Lubricated Plug Valve



Walworth
Steel Gate Valve



Walworth
Iron Body Gate Valve

Walworth
"500 Brinell" Bronze Globe Valve

Walworth
Iron Body Saddle Gate Valve

Walworth
Cast Steel Flanged Fittings

SINCE THE BEGINNING OF THE PETROLEUM INDUSTRY Walworth has been supplying producers and refiners with the quality products they demand...

The petroleum industry knows that years of engineering experience and development are back of all Walworth Valves and Pipe Fittings. Quality of workmanship, design and material are combined in every Walworth product to assure long years of trouble-free service.

The valves and fittings shown here are typical of Walworth's complete line of steel, iron, bronze, and special alloy valves and fittings.

You can get all the facts about the complete Walworth line in the 600 page Catalog 47. Write for a copy.

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valves and fittings

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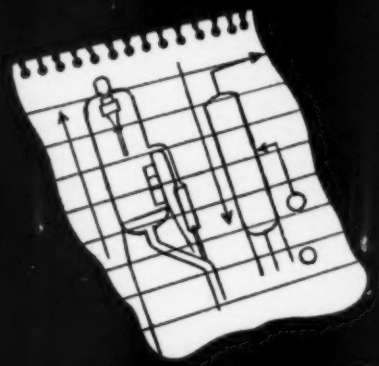

FULFILLMENT

Fulfillment of contractual guarantees in plant design and construction is to be expected of any well qualified organization. It becomes a basis for preference as engineering commitments are consistently surpassed. Lummus stands ready for evaluation on whatever scale of values means the most to you: output, completion dates, or long initial runs. But the test that Lummus regards as the best evidence of its ability to fulfill your needs is its record of success in bringing *new-process* plants from pilot stage to full-scale operation.

teamwork
economy
perspective
resourcefulness

LUMMUS designs and builds with **FULFILLMENT** technique

FULFILLMENT (plant capacity)

A catalytic cracking plant, designed for 5400 B/D, was boosted to 6000 B/D on the 85th day of its initial run. Guaranteed percentage yield of high octane gasoline was also exceeded: 3070 B/D of 10-lb. RVP gasoline against a 2040 B/D guarantee.

FULFILLMENT (initial run)

A long initial run accurately forecasts long-term performance almost every time. This 10,000 B/D catalytic cracking plant was first shut down (for inspection) after 240 days on stream. No major maintenance was necessary. Total turnaround time was some 10,000 manhours.

FULFILLMENT (continuous output)

A continuous processing record for this customer—over 1,200,000 barrels of crude—was established by this Lummus high-pressure cracking unit—on the line for 124 days.

FULFILLMENT (completion schedule)

A polyform gas reversion plant, designed to produce 4000 B/D of high octane gasoline, was completed on a tight 10-month schedule. The acceptance test run met all guarantees. The initial run continued 65 days before shutdown for employee-training purposes.

THE LUMMUS COMPANY
420 Lexington Avenue, New York 17, N. Y.

LUMMUS

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HOUSTON—Mellie Esperson Bldg., Houston 2, Texas

The Lummus Company, Ltd., 525 Oxford St., London, W-1, England

Société Française des Techniques Lummus
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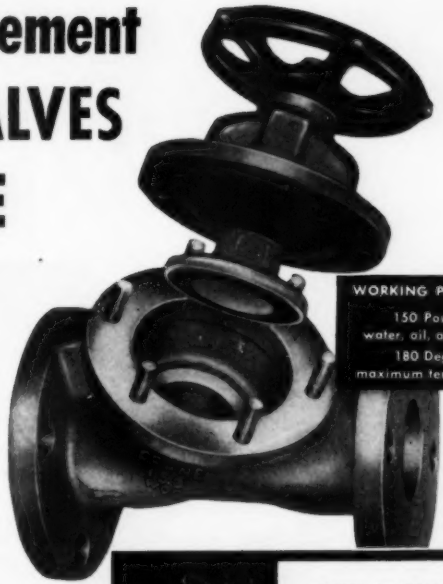
outstanding improvement in DIAPHRAGM VALVES by CRANE



NEW SEATING ARRANGEMENT MORE DURABLE... SAFER... MORE EFFICIENT

Now, after completing exhaustive tests, Crane presents this better diaphragm valve—better suited for more services under today's working conditions. Stemming from basic improvements, such as the radically new bonnet-sealing and valve-seating arrangement, this original Crane design introduces many outstanding service features like those shown here.

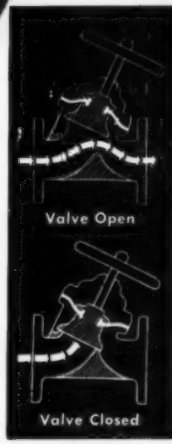
1. LONGER DIAPHRAGM LIFE, because diaphragm is used *only* to seal the bonnet—not for seating purposes.

2. POSITIVE SHUT-OFF in case of diaphragm failure. This is an exclusive Crane safety feature.

3. ACCURATE SEATING—new flat face disc with durable, resilient seating surface assures tight closure on all fluids.

4. GREATER FLOW CAPACITY with reduced resistance and pressure drop, assured by Crane Y-pattern body design.

5. EASIER OPERATION—Crane separate disc and diaphragm construction takes less torque—fewer turns—to operate.



HOW IT WORKS

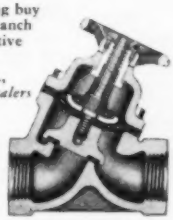
The Crane diaphragm serves one function only—sealing the bonnet. It is not subject to crushing and rapid wear. The seating member is a separate circular flat face disc, firmly attached to the stem and joined to the diaphragm with a special leakproof connection. This independent seating feature permits positive shut-off with no loss of fluid, even in case of diaphragm failure.

GET THIS DESCRIPTIVE CATALOG

See these new valves—the outstanding buy in their class—at your local Crane Branch or Wholesaler. Or write for descriptive catalog AD-1761.

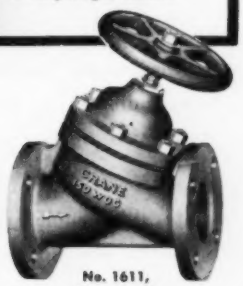
CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill. *Branches and Wholesalers Serving All Industrial Areas.*

This new Crane line includes iron valves with screwed ends in sizes ½ to 2 in.; with flanged ends from ½ to 4 in. Neoprene coated valves—flanged ends only—in sizes from ½ to 4 in.



No. 1610, screwed ends

No. 1615, flanged ends, neoprene coated



No. 1611, flanged ends

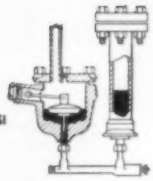
EVERYTHING FROM . . .

VALVES
FITTINGS
PIPE

CRANE

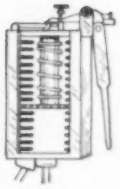
PLUMBING
AND
HEATING

FOR EVERY PIPING SYSTEM



0 TO 10 PSI

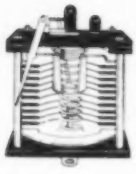
30 TO 10,000 PSI



0 TO 30 PSI (ABSOLUTE)

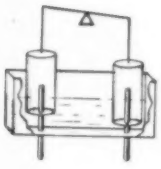
Here's where to start

14 TO 4,000 PSI



10 TO 17 PSI

5 TO 30 PSI



FURNACE PRESSURE DRAFT

FOR PRECISE PRESSURE CONTROL

These measuring elements are the heart of Brown pressure control systems for the Petroleum Industry . . . because precision control starts with precise measurement!

Complete coverage of pressure problems necessitates this complete line of elements. There's a specific one for each application . . . from microns to tons . . . from corrosive to non-corrosive! They make Brown Pressure Gauges *the finest available to the Petroleum Industry!*

You'll find detailed information in Catalog 7000 . . . send for it today!

MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
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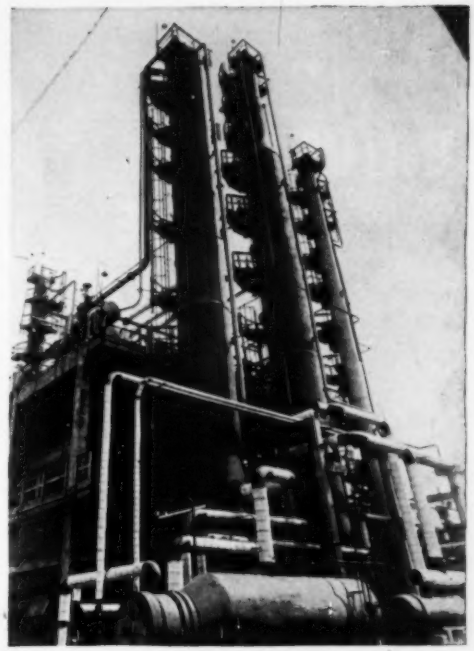
BROWN *Advanced Instrumentation* FOR THE PETROLEUM INDUSTRY
Product of MINNEAPOLIS **Honeywell**

Corrosion Worries ?



When your worries are due to stud failures in corrosive applications, it's high time to switch to dependable Republic Upson Alloy Studs. These tough, long-lasting studs offer effective resistance both to corrosion and high temperatures . . . turn off as freely as they go on when it is necessary to open lines for purging and blowing down.

Better yet, start out right by specifying Republic Upson Alloy Studs in new equipment before corrosion worries begin.

REPUBLIC STEEL CORPORATION
BOLT & NUT DIVISION • CLEVELAND 13, OHIO
Export Department: Chrysler Building, New York 17, New York

Made from Alloy Steel—from the furnaces of Republic, world's leading alloy steel producer.

REPUBLIC *Upson Quality* **ALLOY STEEL STUDS**

REPUBLIC STEEL

Other Republic Products Include Machine, Tank and Carriage Bolts—Lag Screws, Cap Screws and Rivets

UNIVERSAL
SERVICE

UOP

New Fluid Unit to Boost Capacity at Rock Island

By L. E. Kincannon
Vice President and General Manager
Rock Island Refining Corporation

When Rock Island's new fluid catalytic cracking unit goes on stream in July, we expect to increase our capacity to 10,000 b/d. The changes in processing equipment will result in improved gasoline and increase in middle distillates and a reduction in the yields of residual fuel oil.

L. E. Kincannon

Our refinery, near Indianapolis, Ind. now processes about 8,500 b/d, and while we have made maximum use of our existing equipment through efficient waste heat utilization, we anticipate considerable improvement in yield with the new unit. This is shown in the comparison of our present and projected yields shown below.

Comparison of Yields

	Percent Present (Thermal Cracking)	Percent Expected (Cat Cracking)
80 Octane Gasoline..	48.5*	50.0**
Stoddard Solvent	3.0	3.0
Kerosene	15.0	12.5
No. 3 Fuel.....	6.5	17.0
No. 5 Fuel.....		3.6
No. 6 Fuel.....	22.0	10.0
LPG		1.9
Total Recovery.....	95.0	98.0

*Requires 3 cc TEL
**Requires 1.75 cc TEL

The original plant, built in 1941, consisted of a crude oil heater and fractionator, a vacuum unit, a combination thermal cracker and reformer and necessary auxiliaries. Rated capacity was 5,000 b/d. Within six months after operations were begun, however, capacity was raised to 6,000 b/d with the use of heat exchangers.

In 1945, a catalytic polymerization unit was installed, producing 250 b/d of polymer, thus raising the octane of the gasoline output. In 1946, additional heaters further increased our capacity.

Having boosted our capacity to about 8,500 b/d, we felt we had reached the limits of our existing equipment. After a thorough study of the UOP Improved Fluid Catalytic Cracking Unit and comparisons with other available processes, we requested Universal Oil Products to design a unit for us. This unit, with a capacity of 5,000 b/d, is now under construction.

The New Unit

The new cat cracker, like others of the type designed by Universal, has been planned to use existing equipment as far as possible. For example, the fractionator on the thermal unit was large enough to handle the capacity of the cat cracker. It had sufficient trays to fractionate the gasoline, and space for addi-

(Advertisement)

tional trays to fractionate between the furnace oil and heavy cycle fuel oil. A small auxiliary column was needed to accommodate recirculating column bottoms to wash out catalyst fines and take out the small amount of slurry oil.

The present poly unit is large enough to handle the cracked gases, removing olefins from the gas as polymers. A new Universal-designed LPG unit will handle higher paraffins from the poly unit.

Operating Plan

Five thousand b/d of charging stock enters the cat cracker at about 500° F. and is joined by about 2,000 b/d of heavy recycle from the fractionating column and 250 b/d of slurry oil returning entrained catalyst to the reactor. This combined feed enters the bottom of the riser contacting hot catalyst descending from the regenerator, and is vaporized by the heat in this catalyst and carries the catalyst up into the bottom of the reactor. The oil vapor rises through the reactor and leaves by way of cyclone separators that remove practically all of the catalyst, then goes into the bottom of the auxiliary column.

A stream of oil is recirculated from the bottom of this column through a steam generator and back over the lower pans in the column. The stream washes down catalyst and condenses about 500 b/d of heavy slurry oil. This slurry is taken from the pump discharge to the settler where half of it is clarified and taken to storage. The rest, carrying catalyst, is recycled from the settler to join the combined feed.

Vapors from the auxiliary column pass to the bottom of the main fractionating column, the bottoms from which are pumped to four streams. The first is cooled and recycled over the lower pans of the fractionating column to control split between furnace and heavy fuel oil.

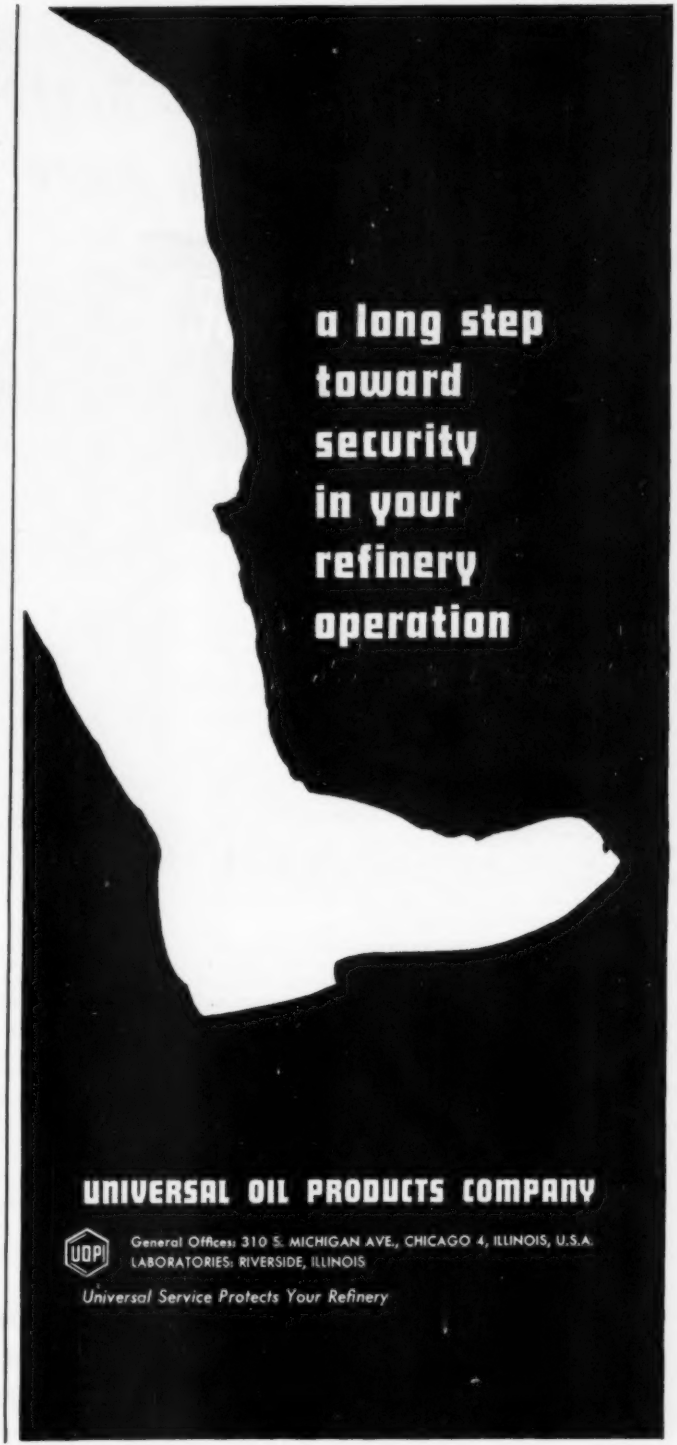
The second is pumped back over the top of the auxiliary column as reflux. The third forms the 2,000 barrels of recycle to the combined feed, and the fourth stream is stripped and goes to storage as heavy fuel oil.

Furnace oil from a center well in the fractionating column is circulated through another steam generator and returns to the column three decks above, for cooling and assisting in heat balancing the column. The furnace oil product flows from the center well through a stripper and is pumped to storage. A small naphtha stream is taken from the fourth deck, stripped, and used as a sponge medium in the top of the absorber. The distillate and gas pass overhead and are condensed.

Simplified Construction

As contrasted with earlier cat crackers, the function of the fractionating tower has been split between two vessels, removal of catalyst carry over and residual fuel oil being done in an auxiliary column. In order to save space and vessel construction, this auxiliary column and the slurry settler, although functionally distinct, were constructed as one unit and separated into two compartments by a head.

(Advertisement)



THEY'RE *New -- Better, Cheaper and More Efficient*

BROWN FINTUBE *Thermo-Flo* TANK HEATERS

● Brown Fintube THERMO-FLO Tank Heaters are service proved — and offer many advantages as compared to the old method of using a bare pipe coil on the bottom of the tank.

EASY INSTALLATION—THERMO-FLO heaters are compact units. They will pass through a standard 20 inch manway with ample clearance.

REDUCED FOULING—The vertical mounting practically eliminates depositing on the tubes, and avoids the necessity of heating through a layer of sediment.

EFFICIENT HEAT TRANSFER—THERMO-FLO heaters set up a thermal siphon or "flow" within the tank, resulting in highly efficient heat transfer — and avoiding stratification.

LOW VOLUME DISPLACEMENT—Due to Brown's exclusive finned tube construction, each lineal foot of fintube in the THERMO-FLO heater has the surface equivalent of 6 lineal feet of plain bare pipe.

STURDY CONSTRUCTION—THERMO-FLO heaters are built to a standard design — in low-cost production quantities — and are completely assembled and tested before shipment.

INEXPENSIVE—Users report that the cost of a group of Brown Fintube THERMO-FLO heaters — plus their installation — is *less* than just the installation of a bare pipe coil having equivalent heating capacity.

EASY MAINTENANCE—THERMO-FLO heaters can be removed from the tank easily and repaired or cleaned *outside* the tank,— or a damaged heater can be replaced with another standard heater from stock.

HIGHLY FLEXIBLE—THERMO-FLO heaters can be installed in new or existing tankage and additional units can be added to meet changing conditions.

MEET ANY REQUIREMENT—THERMO-FLO heaters can be installed singly or in groups. Fabricated from mild steel, stainless steel, monel, everdur, admiralty or other metals, to meet individual conditions.

Bulletin No. 491 Gives Full Details. Write for a copy. Today!

THE BROWN FINTUBE CO.
ELYRIA, OHIO

FINTUBE HEAT TRANSFER PRODUCTS

Recent Advances

in the technology of industrial chemicals, synthetic rubber, plastics, dyes, soaps, high octane gasoline, pharmaceuticals, paper and textiles have been paralleled by equally important developments in the field of Stainless Steel.

THE versatility of this superior corrosion-resisting and heat-resisting steel group has in recent years been constantly extended so that it is generally safe to say:—*the more severe the service the greater the need for Stainless Steel.*

In U·S·S Stainless Steel we offer perfected, service-tested Chromium and Chromium-Nickel Stainless Steels, not only in different analyses but in the most complete range of forms, sizes and surface finishes available anywhere.

Our engineers, who are specialists in the use of stainless steels, have behind them the research and laboratory facilities of the world's largest producer of fine steels. These facilities are available to tackle your problems where they involve severe or unusual applications.

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO · CARNEGIE-ILLINOIS STEEL CORPORATION, PITTSBURGH & CHICAGO
COLUMBIA STEEL COMPANY, SAN FRANCISCO · NATIONAL TUBE COMPANY, PITTSBURGH · TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM
UNITED STATES STEEL SUPPLY COMPANY, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST · UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

U·S·S STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

9-730

UNITED STATES STEEL

Johns-Manville

Announces...

...sets a new high of 3000 F for insulating fire brick service

• Here is a new insulating fire brick, especially developed by the Johns-Manville Research Laboratory for use in forge furnaces, ceramic kilns, chemical process furnaces and other types of high-temperature equipment operating above the previous range of insulating fire brick.

Some of the more outstanding advantages of JM-3000 Insulating Fire Brick are: It is the highest temperature insulating fire brick made for backup or exposed use, effectively withstanding the full 3000 F. Its efficiency remains at a high level throughout the life of the brick. It has exceptional service advantages in many operations at lower temperatures where regular or special fire brick is ordinarily used.

With its combination of outstanding insulating and refractory properties, JM-3000 Insulating Fire Brick has been found to provide longer life, greater fuel economy and important savings in downtime. For further information, write to Johns-Manville, Box 290, New York 16, N. Y.

PHYSICAL AND THERMAL PROPERTIES

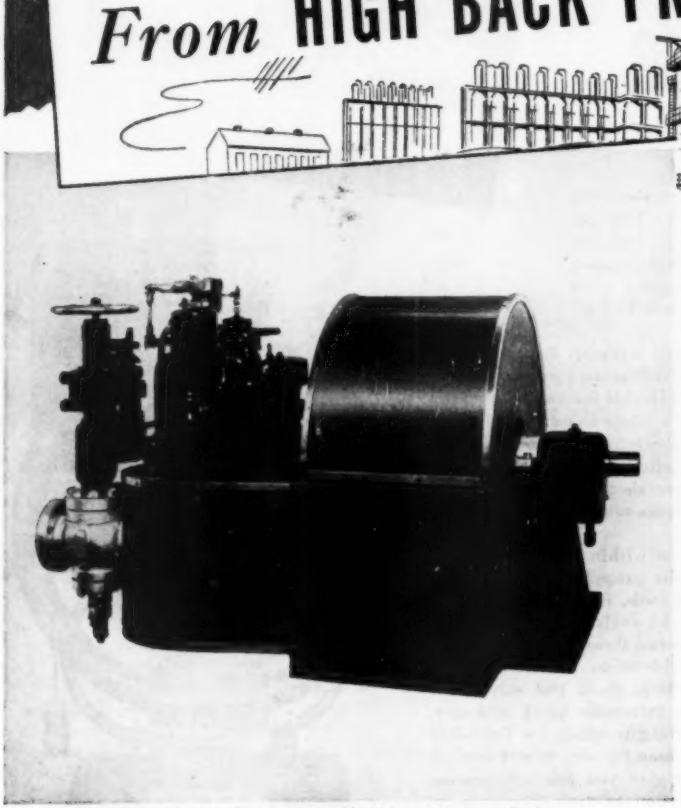
Molded from high quality kaolin clays plus alumina
Density—63-67 lb per cu ft
Modulus of rupture—200 lb per sq in.
Linear shrinkage—(24 hr Panel test @ 3000 F) .8 per cent
Linear thermal expansion to 2000 F—.5 to .6 per cent
Pyrometric cone equiv.—Cone 37+ (3308 F+)
Temperature limit—3000 F

Conductivity (Btu in. per sq ft per F per hr at mean temp)

F	500	1000	1500	2000
Btu	3.10	3.20	3.35	3.60

Johns-Manville *First in* INSULATIONS

Getting LOW COST POWER *From* HIGH BACK PRESSURE



A Worthington Single-Stage High Back Pressure Turbine for Mechanical Drive

Worthington

Topping Turbines Make Steam Do More Work

Here's how to take full advantage of the increased power-potential of high-pressure, high-temperature steam! Exhausting at pressures ranging from 100 to 250 lbs., Worthington Single-Stage High Back Pressure Turbines are specifically built for this type of operation. Features like the following tell you why:

Extra heavy, all steel casing . . . separate steam chest of alloy steel . . . centerline support compensates for casing expansion . . . high back pressure packing gland . . . water cooled or force feed lubricated bearings . . . balanced governor valve . . . horizontally split casing . . . steam and exhaust connections in lower half . . . lagged, sheet-metal-jacketed casing . . . and constant or variable speed governors, direct acting or oil relay type.

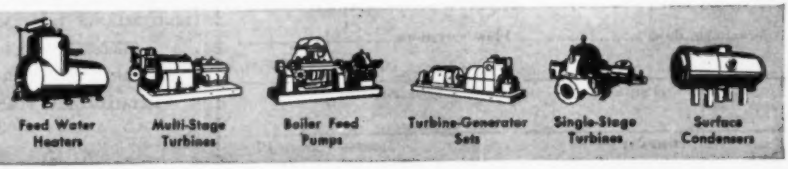
Built in sizes from 50 to 2000 hp, Worthington High Back Pressure Mechanical Drive Steam Turbines develop speeds up to 10,000 rpm. Consistently cutting fuel and maintenance costs in such drives as centrifugal compressors, pumps, fans, and blowers, they are proving to refineries everywhere that *there's more worth in Worthington*. For details, write to *Worthington Pump and Machinery Corporation, Steam Turbine Division, Wellsville, N. Y.*

WORTHINGTON

STEAM TURBINES

TB-6

A GREAT TEAM IN STEAM



The **best** test meter

because it is the *most flexible*

HAGAN
Ring-Balance
FLOW METER

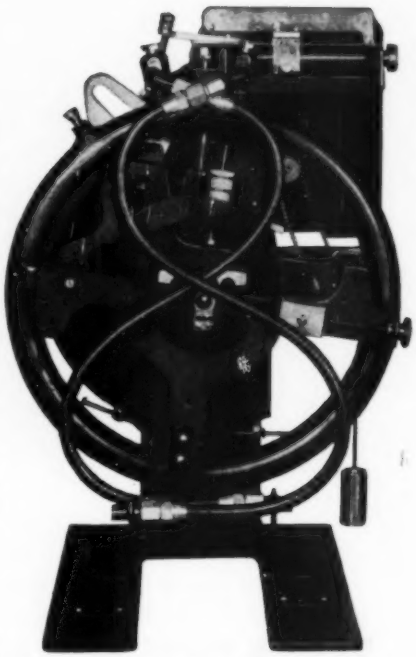
When you choose a meter for test service, you want maximum accuracy, of course. You get that in Hagan Ring Balance Meters, but you get considerably more than that. You get, among other advantages, a degree of flexibility as to differential pressures that isn't approached by any other meter.

A standard Hagan meter equipped with an R-80 ring, for example, is suitable for a range of differential pressures from 20 to 140 inches of water, and you adjust it for any differential within this range by simply turning a range screw. This feature of the adjustable meter differential permits using full scale for maximum flow on each test without altering the existing orifice. Other rings are suitable for differentials as low as ½ inch of water, and as high as 420 inches. Rings are available for static pressures up to 10,000 p.s.i.

If the test differential range is not within the present ring, it can be replaced by one having the proper range in a short time and without the use of special tools. For still greater convenience in test work, two flows may be analyzed simultaneously with the dual meter which records the two flows on a single chart.

Calibration is an important consideration in meters which are to be moved from place to place, as in test service. In Hagan Ring Balance Meters this is extremely quick and easy, requiring merely the use of check weights which are furnished with the meter. Calibration is the same for dry or wet service.

Hagan engineers will be glad to give you full information about Ring Balance Meters in relation to your own requirements. Write us about them, or fill out the coupon below.



The R-80 ring shown in this meter is suitable for differentials from 20 to 140 inches of water. Three interchangeable rings, such as the R-22 (1" to 5"), R-82 (5" to 40") and the R-98 (40" to 280") would cover a full range of differentials from 1" to 280".

HAGAN CORPORATION—Hagan Building
323 Fourth Avenue, Pittsburgh 30, Pa.

I am interested in the Hagan Ring Balance Meter for testing service under the following conditions:

Fluids to be metered _____ Orifice sizes _____

Differential Pressures _____ Static Pressures _____

Approximate flow _____ Flow variations _____

NAME _____ POSITION _____

COMPANY _____ ADDRESS _____ PR-6

HAGAN CORPORATION

RING BALANCE FLOW AND PRESSURE INSTRUMENTS

THRUSTORQ FORCE MEASURING DEVICES

BOILER COMBUSTION CONTROL SYSTEMS

METALLURGICAL FURNACE CONTROL SYSTEMS

For a processing problem like this...

"...severe corrosive conditions resulting from high sulphur content of sour crude oils..."

NATIONAL TUBE might recommend:

ANALYSIS No. 12*

Type of Steel—5 Chromium, ½ Molybdenum

In equipment involving severe corrosive conditions such as processing of very sour crude oils containing large amounts of sulphur, only the higher chromium compositions, such as 5% Cr, .5% Mo stabilized or the 18-8 alloys are recommended.

FINDING the answer to refinery tubing problems isn't always as easy as the above instance might indicate. But when NATIONAL does come up with a recommendation, you can depend on it being the best possible for your particular case.

How can we justify such a statement? Because we study conditions as they actually exist in your plant (usually from what you tell us; sometimes by sending a tubing specialist for a personal observation). We then check the information thus obtained against our large and growing file of past problems involving similar conditions which have been successfully solved with NATIONAL Seamless Pipe and Tubes. That's how NATIONAL developed many of the *25 different* analyses of Still Tubes, Condenser and Heat Exchanger Tubes, and Refinery Piping which we now offer the industry. We call it our "Complete Tube Service."

We invite you to bring your problems to NATIONAL. It's the easy, proven way to select the *proper* refinery tubing for your plant. An inquiry entails no obligation . . . and our recommendations may solve your problem.

NATIONAL TUBE COMPANY, PITTSBURGH, PA.

(Tubing Specialties Division)

COLUMBIA STEEL COMPANY, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

NATIONAL TUBE offers you

Seamless Steel Still Tubes · Condenser Tubes
Heat Exchanger Tubes · Refinery Piping in

25 DIFFERENT ANALYSES

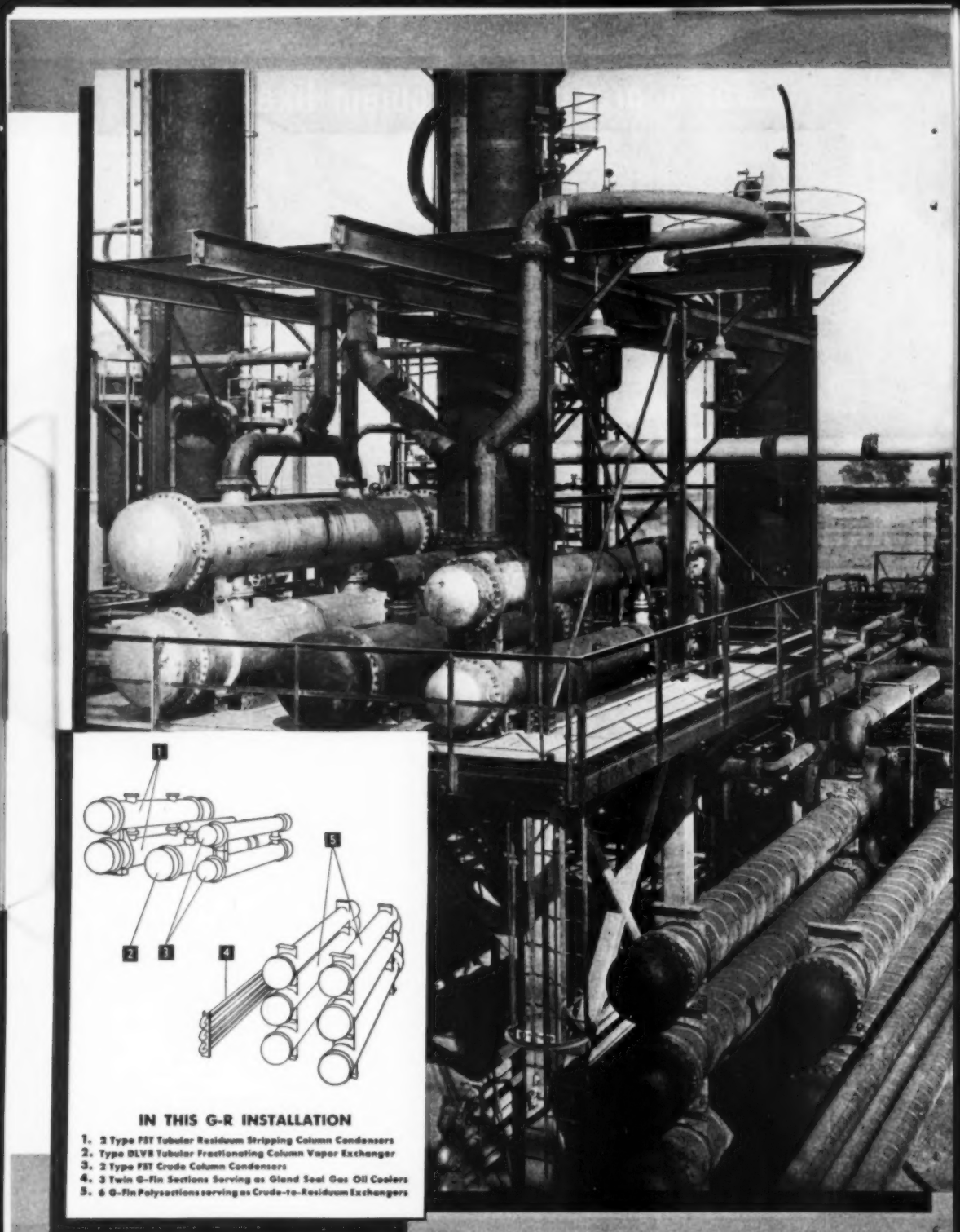
- Low Carbon
- Low Carbon, ½ Moly.
- Low Carbon, 1 Moly.
- ⅓ Cr., ½ Moly.
- 1¼ Cr., ½ Moly.
- 2 Cr., ½ Moly.
- 2 Cr., ½ Moly., 1¼ Sil.
- 2¼ Cr., 1 Moly.
- 2½ Cr., ½ Moly., ¾ Sil.
- 3-Cr., ½ Moly., 1¼ Sil.
- 3-Cr., 1 Moly.
- 5-Cr., ½ Moly.
- 5 Cr., ½ Moly., 1½ Sil.
- 5 Cr., ½ Moly., Titanium
- 5 Cr., ½ Moly., Columbium
- 7 Cr., ½ Moly.
- 8 Cr., 1 Moly.
- 9 Cr., 1 Moly.
- 12 Cr., Aluminum.
- 17 Cr.
- 18-8
- 18-8 Titanium
- 18-8 Columbium.
- 18-8 Molybdenum.
- 25-20

SEAMLESS WITHOUT WELDS

USS

NATIONAL SEAMLESS PIPE AND TUBES

UNITED STATES STEEL



IN THIS G-R INSTALLATION

1. 2 Type FST Tubular Residuum Stripping Column Condensers
2. Type DLVB Tubular Fractionating Column Vapor Exchanger
3. 2 Type FST Crude Column Condensers
4. 3 Twin G-Fin Sections Serving as Gland Seal Gas Oil Coolers
5. 6 G-Fin Polysections serving as Crude-to-Residuum Exchangers

GRISCOM-RUSSELL: PIONEERS IN HEAT TRANSFER APPARATUS

Meet this G-R family group of HEAT TRANSFER APPARATUS

In the illustration on the adjoining page, you will find some of the large family of G-R heat transfer apparatus. This particular group includes finned tube and bare tube units . . . condensers, heat exchangers, and coolers.

Many additional G-R units, not shown in the illustration, and including condensers, heaters, coolers, subcoolers, reboilers, and heat exchangers on a great variety of services were also furnished for this representative plant.

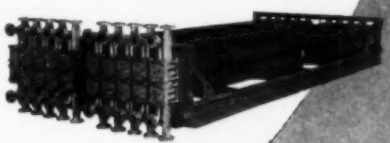
Throughout the petroleum industry in the United States and abroad, in refineries, natural gas and gasoline plants, and in pipe line pumping stations, G-R heat transfer apparatus has made records of effectiveness, economy, and durability on standard and special services. To assure best results in your heat transfer operations, standardize on G-R apparatus.

THE GRISCOM-RUSSELL CO.
285 Madison Avenue, New York 17, N. Y.

SOME STANDARD DESIGNS OF G-R HEAT EXCHANGERS

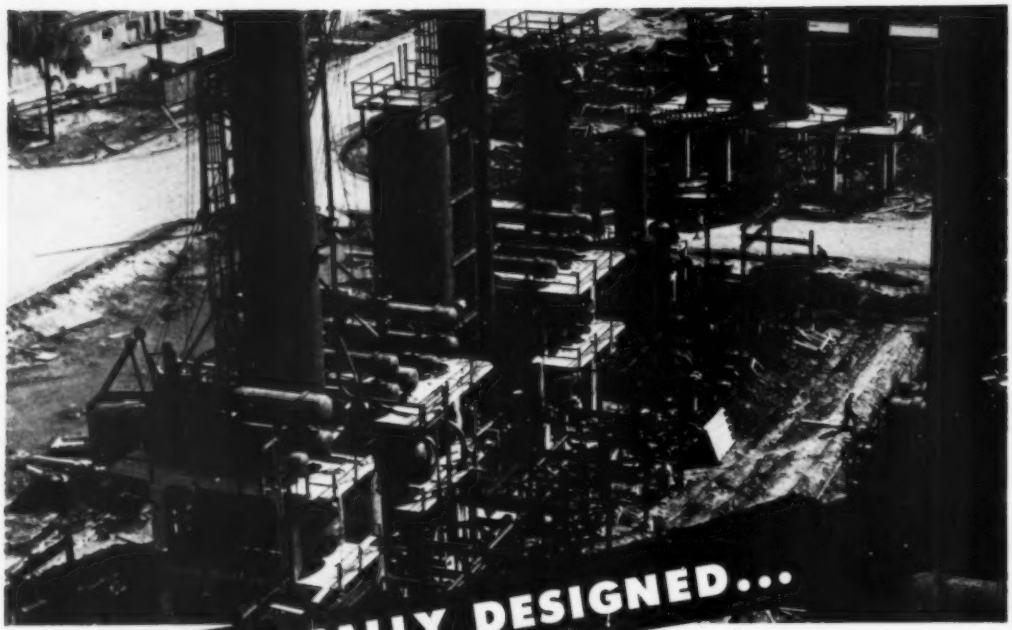
G-R Twin G-Fin Section — with finned type heat transfer elements that compensate for the unequal heat transfer rates of fluids of high and low heat conductivity.

G-R Tubular Exchanger—with several distinctive features that provide most effective heat transfer and minimum maintenance expense.



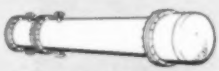
G-R Tubeflo Section—the only design of heat transfer apparatus that maintains rated capacity with clogging or dirty fluids.

GRISCOM-RUSSELL



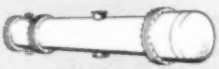
SPECIFICALLY DESIGNED...

FOR THE REQUIREMENTS OF THE JOB!

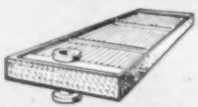


HEAT EXCHANGERS

REBOILERS



CONDENSERS



ATMOSPHERIC SECTIONS
(Horizontal and Vertical)

STEAM GENERATORS

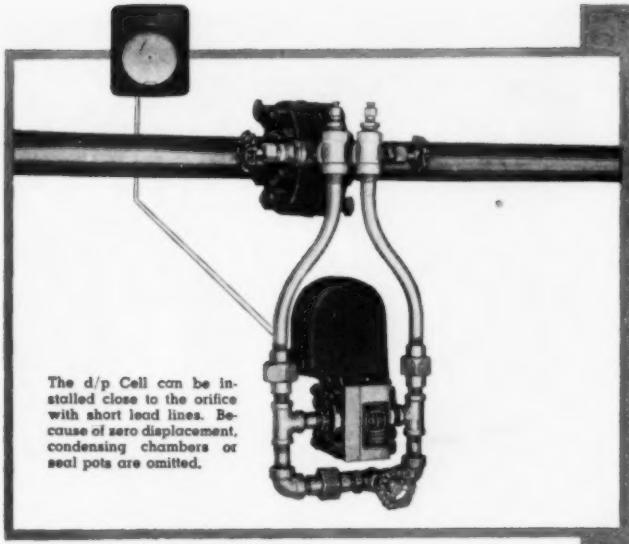
JACKET WATER COOLERS

EFCO HEAT TRANSFER EQUIPMENT

● EFCO engineers can supply you with any type of heat transfer equipment to meet your specifications. Reboilers, condensers, atmospheric sections, jacket water coolers, steam generators and heat exchangers, made by EFCO specialists, are sturdily constructed to give long trouble-free service. Ask an EFCO engineer. He will be glad to help you with your heat transfer problems.

ENGINEERS & FABRICATORS, INC.
P. O. Box 7395 Houston 8, Texas

EFCO HEAT TRANSFER EQUIPMENT



The d/p Cell can be installed close to the orifice with short lead lines. Because of zero displacement, condensing chambers or seal pots are omitted.

Simpler Flow Measurement

in the palm of your hand

NEW • REVOLUTIONARY • MERCURY-LESS

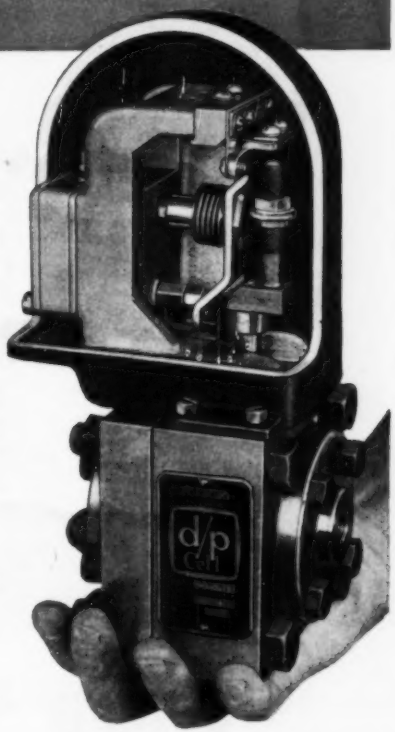
FOXBORO

DIFFERENTIAL PRESSURE CELL

Now you can simplify many troublesome flow problems . . . especially those where corrosion is a factor or the use of mercury is objectionable. This unique flow measuring device is accurate, easily calibrated, and widely applicable, and it weighs only 20 lbs. The Foxboro d/p Cell offers a combination of advantages that no other type of flow measurement can duplicate.

The Foxboro d/p Cell operates on the highly-accurate force-balance principle, transmitting flow measurement to remote, conveniently-located pneumatic receiving instruments (indicating, recording, controlling). Range: 100 in. to 800 in. Maximum working pressures: 500 psi and 1500 psi.

Get all the facts about this revolutionary new device for the measurement of liquid, steam, gas or air flow. Write for Bulletin 420. **The Foxboro Company, 74 Neponset Ave., Foxboro, Mass., U. S. A.**

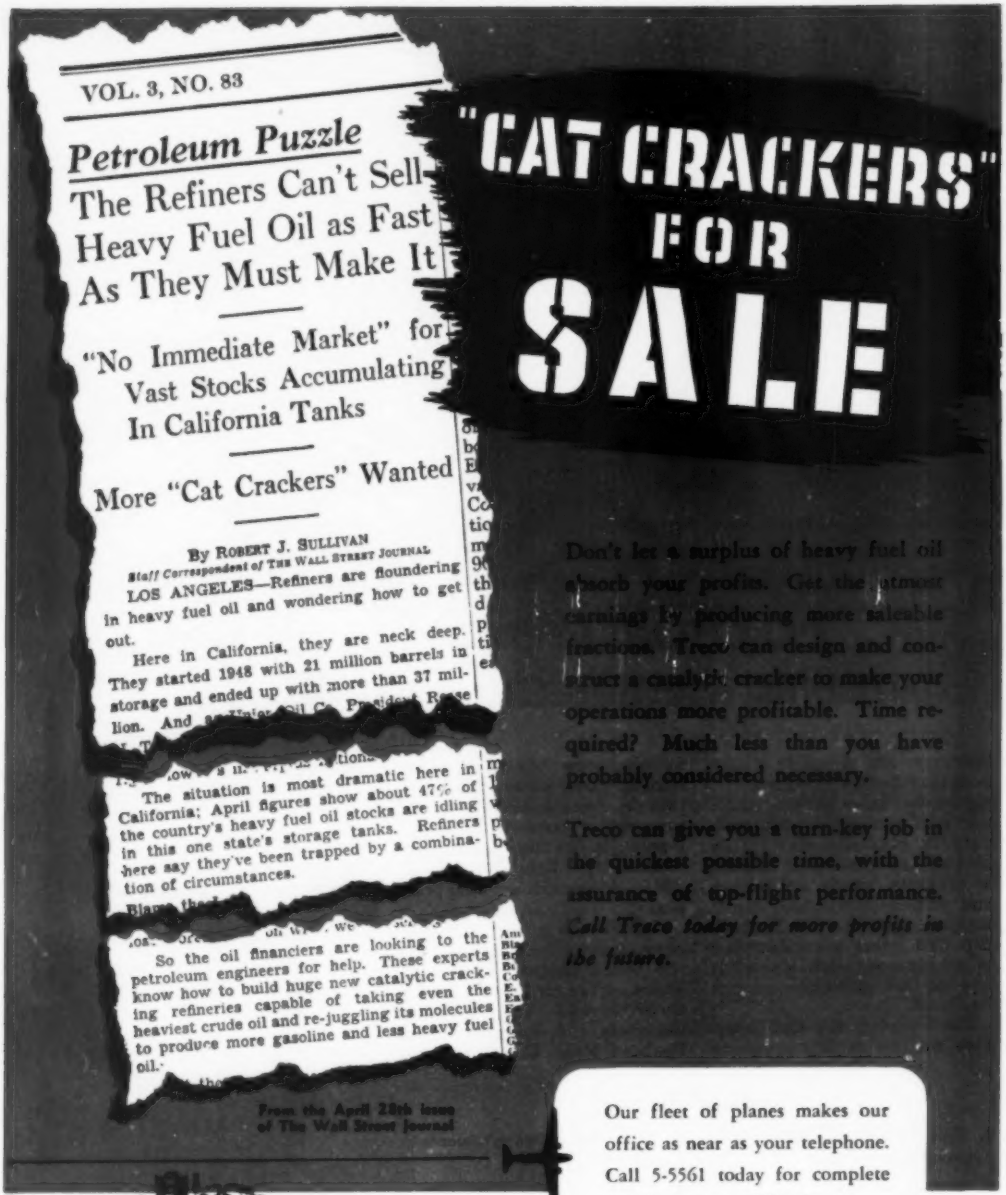


UNIQUE ADVANTAGES

1. Type 316 Stainless Steel Construction.
2. Uses no mercury.
3. Essentially zero displacement—no need for condensing chambers on steam measurement or seal pots on liquid measurement.
4. Immediate, unfailing response to pressure changes.
5. Positive overrange protection.
6. Easy range change.
7. Simple field zero adjustment without disturbing force-balance mechanism.

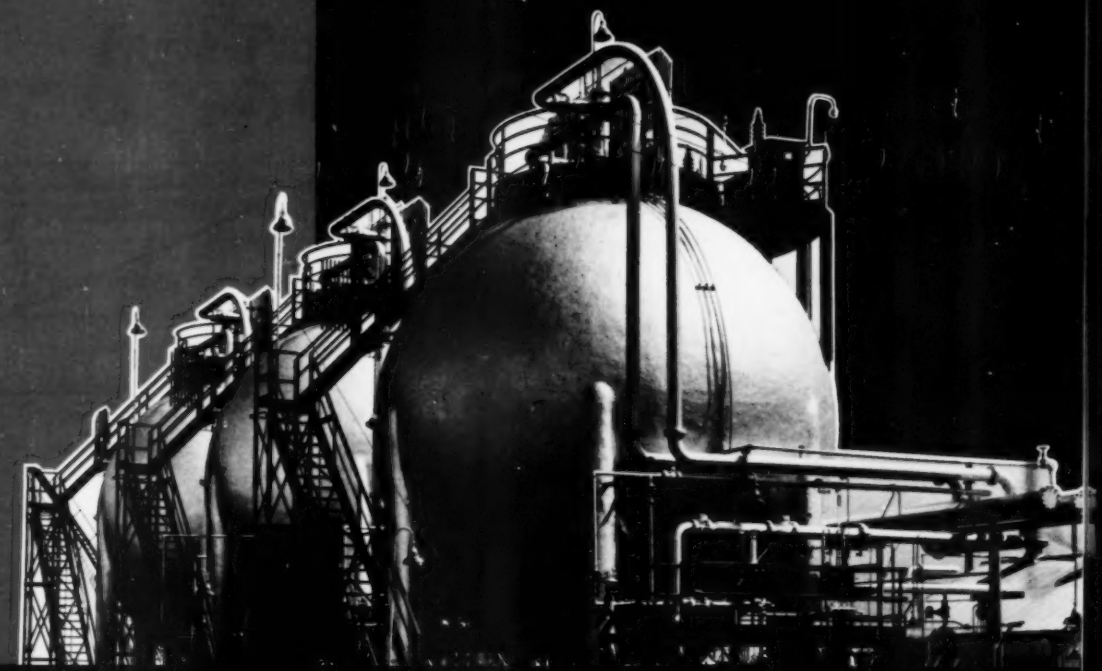
FOXBORO
REG. U. S. PAT. OFF.

RECORDING · CONTROLLING · INDICATING INSTRUMENTS


VOL. 3, NO. 83
Petroleum Puzzle
The Refiners Can't Sell Heavy Fuel Oil as Fast As They Must Make It
"No Immediate Market" for Vast Stocks Accumulating In California Tanks
More "Cat Crackers" Wanted
By ROBERT J. SULLIVAN
Staff Correspondent of THE WALL STREET JOURNAL
LOS ANGELES—Refiners are floundering in heavy fuel oil and wondering how to get out.
Here in California, they are neck deep. They started 1948 with 21 million barrels in storage and ended up with more than 37 million.
The situation is most dramatic here in California; April figures show about 47% of the country's heavy fuel oil stocks are idling in this one state's storage tanks. Refiners here say they've been trapped by a combination of circumstances.
So the oil financiers are looking to the petroleum engineers for help. These experts know how to build huge new catalytic cracking refineries capable of taking even the heaviest crude oil and re-juggling its molecules to produce more gasoline and less heavy fuel oil.
From the April 28th issue of The Wall Street Journal
"CAT CRACKERS" FOR SALE
Don't let a surplus of heavy fuel oil absorb your profits. Get the utmost earnings by producing more saleable fractions. Treco can design and construct a catalytic cracker to make your operations more profitable. Time required? Much less than you have probably considered necessary.
Treco can give you a turn-key job in the quickest possible time, with the assurance of top-flight performance. Call Treco today for more profits in the future.
Our fleet of planes makes our office as near as your telephone. Call 5-5561 today for complete details without obligation.
TRECo
The REFINERY ENGINEERING Co.
Phone 5-5561
Tulsa, Oklahoma

SALT *in the crude charge*

how much is harmful?

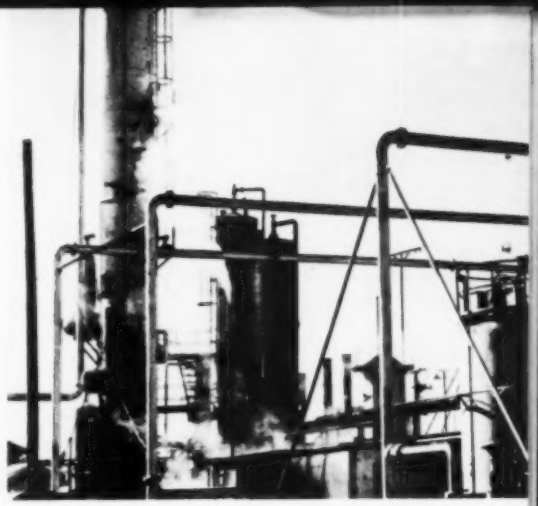


PETRECO DESALTING

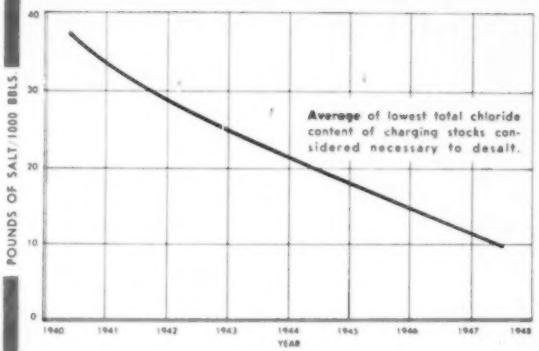
These advantages benefit every **PETRECO** *customer*

24-hour, on-call SERVICE
Regular EQUIPMENT INSPECTION
Available REPLACEMENTS
Complete LABORATORY FACILITIES
Continuing RESEARCH PROGRAM

THE AMOUNT OF SALT CARRIED INTO THE REFINERY EQUIPMENT in the charging crude often reaches surprising proportions. For example: 10,000 barrels of a crude containing only .15% water will often carry close to a half a ton of salts. The potential injury to the refining equipment from the continuous introduction of salts in such quantities can easily be visualized. Some desalters operate on crudes that carry from 500 to 800 pounds of salt per thousand barrels; in other cases, refiners find it profitable to desalt stocks containing even less than 10 pounds per thousand barrels. It is difficult to set any lower limit of acceptable salt tolerance since this depends upon the nature of the salts, the character of the crude, the type of refining equipment and the operating conditions. Furthermore, refiners have found that continued experience with desalting repeatedly reveals benefits which were not expected when the desalters were installed. As a result, they now desalt crude stocks having salt contents formerly considered to be below the economic limit.



THIS TREND IN THE INDUSTRY TO DESALT STOCKS OF PROGRESSIVELY LOWER SALT CONTENT IS GRAPHICALLY SHOWN IN THE ACCOMPANYING FIGURE. The curve is plotted from the electrical desalting records of one refining company and is typical of the trend in the industry as a whole. It reflects the increasing conviction that even oils formerly considered to have negligible salt contents will, with desalting, show beneficial effects to such an extent that the processing is easily justified.



THE DETERMINATION OF SALT is not difficult and is routine with most refiners. For helpful information on salt determinations, request a copy of the PETRECO MANUAL on SALTS IN PETROLEUM (yours for the asking at any Petreco office or from any Petreco engineer). Or, if you prefer, samples of your crude can be sent to the Petreco laboratories and the results of the analysis will be reported to you.

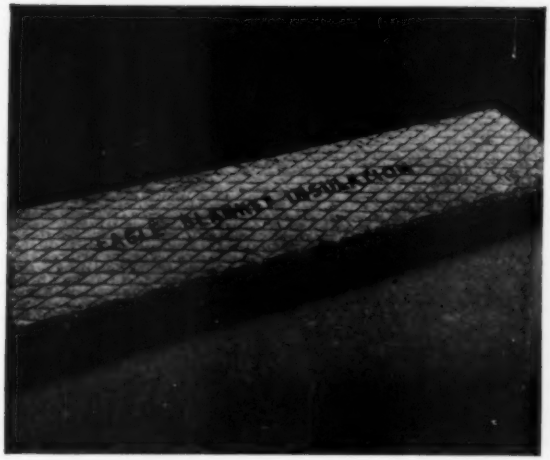
PETROLEUM RECTIFYING COMPANY

5121 South Wayside Drive, Houston 1, Texas
648 Edison Building, Toledo 4, Ohio
530 West Sixth Street, Los Angeles 14, Calif.

PETRECO

SPECIALIZED *Electric* PETROLEUM PROCESSES { DESALTING / DEHYDRATING

PI-49-1



Temperature control demands
EAGLE-PICHER
Insulations

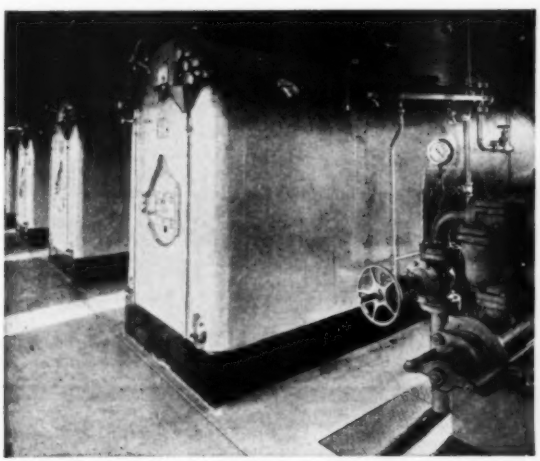
Eagle-Picher Mineral Wool Blankets

are physically and chemically stable!

Long service on heated equipment does not lower the high insulating efficiency of Eagle-Picher Blankets. Their principal ingredient, Eagle-Picher Mineral Wool, does not break down or deteriorate despite continuous exposure to temperatures as high as 1200 F. Outstanding physical and chemical stability enables Eagle-Picher Blankets to permanently resist water, steam, corrosive fumes and normal vibration. Complete technical and application data sent on request.

Let these Eagle-Picher products also save you money...power...time

Insulating Felts
Superlemp Block • Blankets
Loose Wool • Pipe Covering
Stalastic • Insulseal • Insulstic
Swetchek • Finishing Cements
Insulating Cements

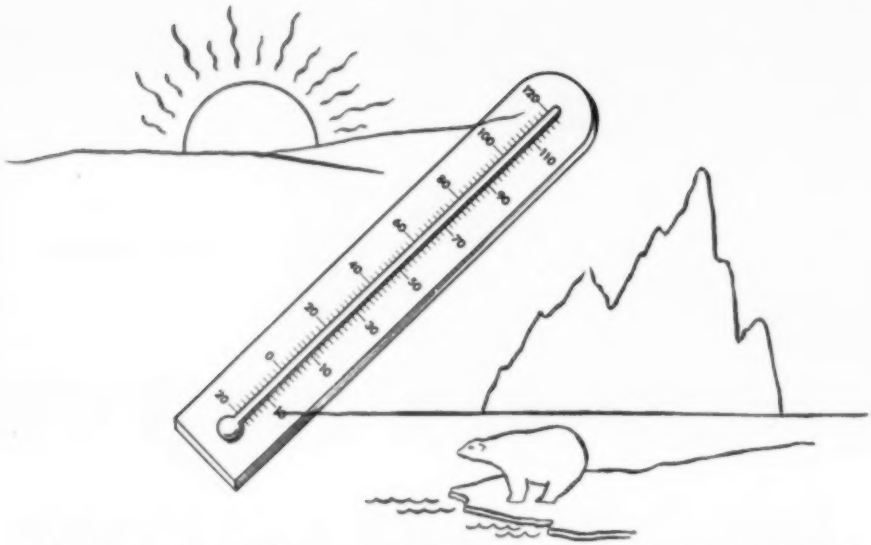


EAGLE-PICHER INSULATIONS for

EAGLE EP PICHER

High and low temperature

Since 1843
THE EAGLE-PICHER COMPANY
CINCINNATI (1), OHIO



where corrosive conditions are very severe

● If in your heat exchange equipment you encounter high temperatures, erosion and high velocity of cooling water, we recommend the use of Wolverine CUPRO-NICKEL.

THESE ARE ITS CHEMICAL AND PHYSICAL CHARACTERISTICS:

Sn. 1.50% max.	Mn. 1.0%
Pb. 0.05% max.	Ni. 33.0%
Fe. 0.6 % max.	Cu. Rem.
Zn. 1.0 % max.	

Density—lbs. per cu. in.	0.323
Specific Gravity	8.94
Thermal conductivity [Btu./(hr.) (ft.²) (°F./ft.) @ 68° F.]	14
Coefficient of expansion	.0000090
Available in O.D. from ⅛″ to 2″	

WOLVERINE—*the name long associated with quality-controlled condenser tubes.*

WOLVERINE TUBE DIVISION
CALUMET AND HECLA CONSOLIDATED COPPER COMPANY
INCORPORATED
MANUFACTURERS OF SEAMLESS NON-FERROUS TUBING
1431 CENTRAL AVENUE • DETROIT 9, MICHIGAN

YOU USE 4 + 8 YOU GET 100,000

That's all it takes! Four basic circuits and 8 basic component parts give you more than 100,000 different electronic instrument combinations for processing use.

Flow, level, speed, pressure, temperature, gas analysis, pH, conductivity, etc.—all can be controlled with these interchangeable Bailey units.

With Bailey controls, replacement part stocks are held to a minimum because parts are interchangeable. Maintenance costs are less, too, because maintenance men quickly become familiar with the standardized Bailey units.

Bailey bulletin No. 17 shows how you can use this improved control system. Write for your copy and keep it handy for reference the next time you need process controls.

P-19-O

BAILEY METER CO.
1043 Ivanhoe Rd. • Cleveland 10, Ohio
BAILEY METER CO. LIMITED, MONTREAL
Controls for the Oil Industry
TEMPERATURE • FLOW • PRESSURE
GAS ANALYSIS • LEVEL • RATIO

4 + 8 Works Here at Wood River Refinery of Shell Oil Company

WHEN WATER IS
HOT...BAD...or EXPENSIVE

FLUOR FIN·FAN HEAT EXCHANGERS

COOL AT LOWEST COST

Hot! Bad! Expensive! When the temperature of the fluid to be cooled is much higher than ambient air temperature, when available water has bad scaling characteristics, or when make-up water is scarce and expensive, then you should definitely investigate the use of a Fluor Fin • Fan heat exchanger.

Guaranteed Performance

Whether used to cool process liquids, water, or gas, Fluor Fin • Fans always fulfill their performance guarantee. You can definitely count on the Fluor guarantee when calculating operating efficiencies.

Fin • Fan cooling units consist of finned tubes, across which air is circulated by variable-pitch fans. They are manufactured and sold by Fluor and the Griscom-Russell Co.

This Fluor Fin • Fan cools 8460 gpm of jacket water for a large pipe-line compressor station.

Guarantee: 162° to 150° cooling at 100° (dry bulb) air.

Performance: as guaranteed

photo by Elwood M. Payne

BE SURE WITH FLUOR

FLUOR

THE FLUOR CORPORATION, LTD.

Los Angeles 22 • NEW YORK • PITTSBURGH
HOUSTON • KANSAS CITY • BOSTON • TULSA
SAN FRANCISCO

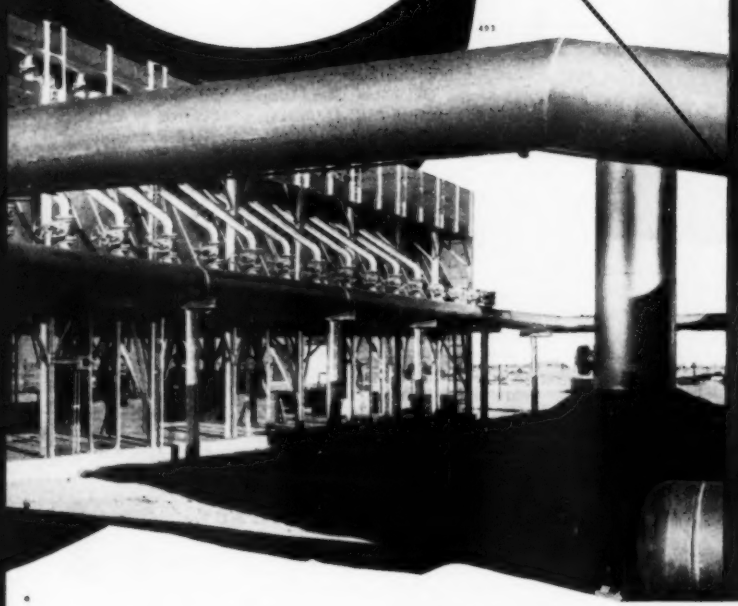
Aerator Towers

Counterflo Towers

Pulsation Dampeners

Gas Cleaners

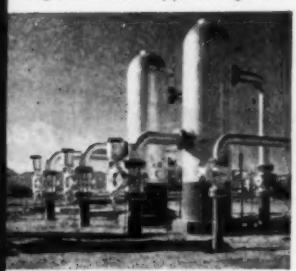
Mufflers



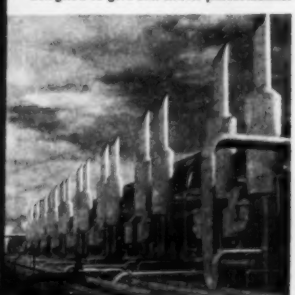
Fluor Aerator cooling towers have distinctive economy features and are most practical in certain cooling applications.

Fluor Counterflo induced-draft cooling towers are a standard of industry for most water-cooling applications. They deliver "colder water cheaper."

Fluor pulsation dampeners remove destructive vibrations and instrument irregularities caused by pulsative gas flow.



The Fluor gas cleaner, already well-known for efficient cleaning, has been redesigned to give still better performance.



Fluor mufflers, redesigned to incorporate pulsation-dampener principles, reduce exhaust-line noises to less than the mechanical noises of the compressor room.

Bethlehem *STOCKS 'EM*

Immediate Delivery of ALLOY STUDS
FROM
LARGE REGIONAL STOCKS
AT HOUSTON, ODESSA,
OKLAHOMA CITY, CASPER

Bethlehem heat-treated alloy-steel continuous-threaded studs for high-temperature use are stocked in required sizes at our convenient Mid-Continent and Gulf Coast store points—Houston, Odessa, Oklahoma City, Casper, and more than 30 others. They are made of AISI 4140, 4142, or 4145 steel to ASTM Specification A193 (latest revision), Grade B7, 1100 F minimum tempering temperature, ***and are threaded to ASA B1.4, Class 7 thread fit.*** These studs also conform to the physical, chemical, and thread requirements of the discontinued ASTM Specification A96, Class C.

Also stocked are Bethlehem Quenched Nuts, which are high enough in tensile strength to break any stud on which they are used. Studs can also be supplied with Bethlehem Treated Nuts. These two classes meet, respectively, ASTM A194 specifications for Grade 2H and Grade 2 nuts. ***Studs and nuts are marked with the ASTM grade symbol to permit ready identification.***

We can also manufacture large-size or extra-length Grade B7 studs for special requirements. These can be shipped promptly from our local plants.

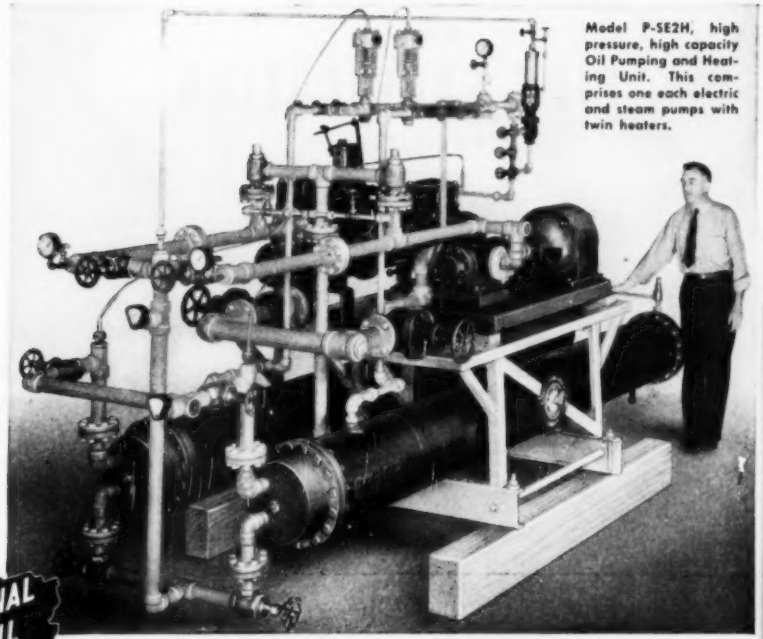
Also available for factory shipment are ASTM Specification A261 (latest revision) Grade BO carbon-steel studs for moderate service conditions, and ASTM Specification A193, Grade B14 alloy-steel studs for more severe conditions.

BETHLEHEM SUPPLY COMPANY
General Offices: 21 E. Second Street, Tulsa, Okla.
Subsidiary of Bethlehem Steel Corporation

BETHLEHEM STEEL

HEADQUARTERS for REFINERY SUPPLIES

COMPACT, SPACE-SAVING...



Model P-SE2H, high pressure, high capacity Oil Pumping and Heating Unit. This comprises one each electric and steam pumps with twin heaters.

NATIONAL AIROIL FUEL OIL - GAS BURNERS

FUEL OIL PUMPING *AND* HEATING UNITS

National Airoil Fuel Oil Pumping and Heating Units are especially designed to prepare, for combustion, all grades of fuel oil including No. 6 or Bunker "C" Oil and residuums. They will draw fuel oil from above ground or underground tanks, preheat it to proper constant temperatures and deliver it to Oil Burners at an even pressure, best suited for the burners. Our Fuel Oil Pumping and Heating Units are the result of years of experience. They come completely equipped ready for: steam, exhaust, condensate, oil suction, oil return, and electrical connections. All valves, regulators, etc. are readily accessible. The piping arrangement is easily understood. These compact, space-saving units are available in a range of sizes and models in both Medium and High Pressure types. For complete details, write for our Bulletin 40—very interesting and informative.

OIL BURNERS and GAS BURNERS for industrial power, process and heating purposes; STEAM ATOMIZING OIL BURNERS; MOTOR-DRIVEN ROTARY OIL BURNERS; MECHANICAL PRESSURE ATOMIZING OIL BURNERS; LOW AIR PRESSURE OIL BURNERS; GAS BURNERS; COMBINATION GAS and OIL BURNERS; AUTOMATIC OIL BURNERS, for small process furnaces and heating plants; FUEL OIL HEATERS; FUEL OIL PUMPING and HEATING UNITS; FURNACE RELIEF DOORS; AIR INTAKE DOORS; OBSERVATION PORTS; SPECIAL REFRACTORY SHAPES.

NATIONAL AIROIL BURNER CO., INC.

Main Offices & Factory: **1254 EAST SEDGLEY AVENUE, PHILADELPHIA 34, PA.**

Texas Office: 2512 South Boulevard, Houston 6

INDUSTRIAL OIL BURNERS, GAS BURNERS, FURNACE EQUIPMENT

complete
PIPE BENDING
and
PIPE FABRICATING
facilities
TEXAS PIPE BENDING COMPANY
PIPE BENDS
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WELDED HEADERS
Pipe Fabricators
HOUSTON TEXAS
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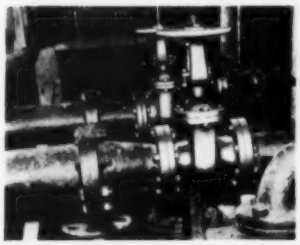
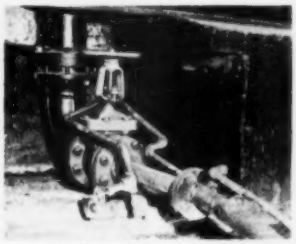
ALOYCO STAINLESS STEEL VALVES

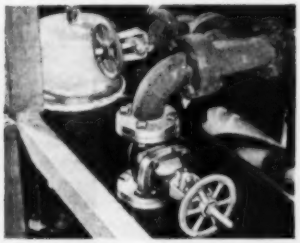
are all over the place at V.C.C.



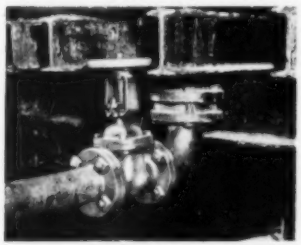
Aloyco 20 Gate Valves on inlet and discharge of 98% acid pumps at 225° F.



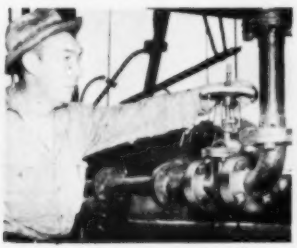
Aloyco 20 Gate Valves on acid storage tank discharge.



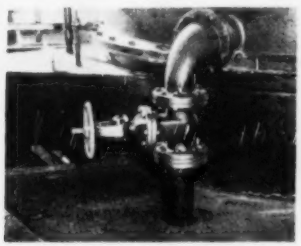
Aloyco 20 Gate Valves in acid control to sample boot at 120° F.



Aloyco 20 Gate Valve in discharge from 98% acid storage tanks—operates about twice per year but never sticks.



Mr. Hilton, Foreman, operating Aloyco 20 Gate Valve on acid sample and drain line.



Aloyco 20 Gate Valve on inlet to drying tower.

Aloyco Valves are just about everywhere in the contact sulfuric acid plant of Virginia Carolina Chemical Corporation in Birmingham, Alabama. A few of the many applications in this contact sulfuric acid unit are shown in the photographs above.

Mr. Hilton, the Foreman, says: "Aloyco Stainless Steel Valves are the best that money can buy." Certainly Mr. Hilton has had ample experience with Aloyco and other makes of valves to back up his opinions.

We believe that you, too, will find Aloyco Corrosion-Resistant Valves "the best that money can buy." Specify Aloyco on your next requisition.

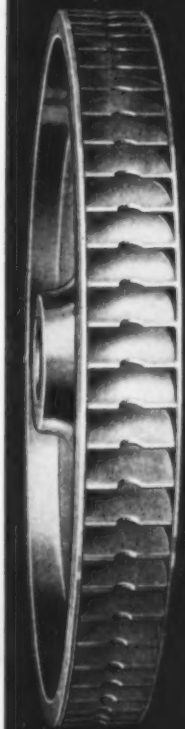
Aloyco Flanged Gate Valve No. 111, 150 lb. Sizes ½" to 12" inclusive. Available in 18-8S, 18-8SMo, Aloyco 20 and other corrosion-resistant alloys.

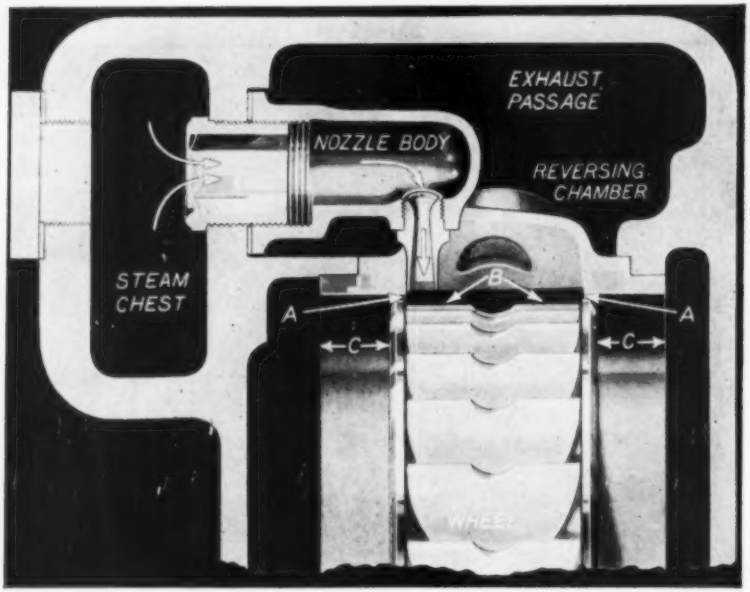
ALLOY STEEL PRODUCTS CO., Inc.

1303 W. ELIZABETH AVE., LINDEN, NEW JERSEY

SALES OFFICES: ATLANTA, CHICAGO, HOUSTON, LOS ANGELES, NEW YORK CITY, PITTSBURGH, WILMINGTON, DEL.

TERRY





AMPLE CLEARANCES FOR DEPENDABILITY

Large blade and rim clearances and extra large side clearance — one inch — help make Terry One-piece Wheel Turbines highly dependable in operation.

The b'ades cannot foul because of the protection afforded by the rims, which are not damaged, should rubbing occur.

Note the rim clearance, AA in diagram. Also the large blade clearance, B. Side clearance, CC, is so large that end-play from external thrust cannot damage wheel.

Terry Bulletin S-116 will give you full information on the Terry Wheel Turbine. A request on your business letterhead will bring you a copy.

T-1171

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

RAISE THE RESEARCH OCTANE RATING OF YOUR CONDENSATE GASOLINES

Cycling plant or condensate gasolines can be upgraded in both Research and Motor Octane values with an economical, efficient PERCO Cycloversion Catalytic Reforming Unit in your plant.

Full scale commercial PERCO operations on cycling plant or condensate stocks are meeting with complete success. Research octane ratings are being raised as much as ten numbers at the 3 cc TEL level with high yields. Catalyst cost is extremely low — actually only a fraction of a cent per barrel.

Install a Perco Cycloversion Catalytic Reforming Unit, the plant that has already been proved by actual construction and operating experience.

Considerable flexibility in processing conditions is possible with Perco Cycloversion Catalytic Reforming to meet varying product specifications. A Perco engineer will gladly explain more fully the benefits you may expect from a Perco application to your cycling plant or condensate stocks.

Write for our latest 28 page brochure, "Pointing the Way to Profits with Perco Processes."

PERCO PROCESSES

PROFIT WITH PERCO PROCESSES

PHILLIPS PETROLEUM COMPANY

CHEMICAL PRODUCTS DEPARTMENT

PERCO DIVISION

BARTLESVILLE, OKLAHOMA

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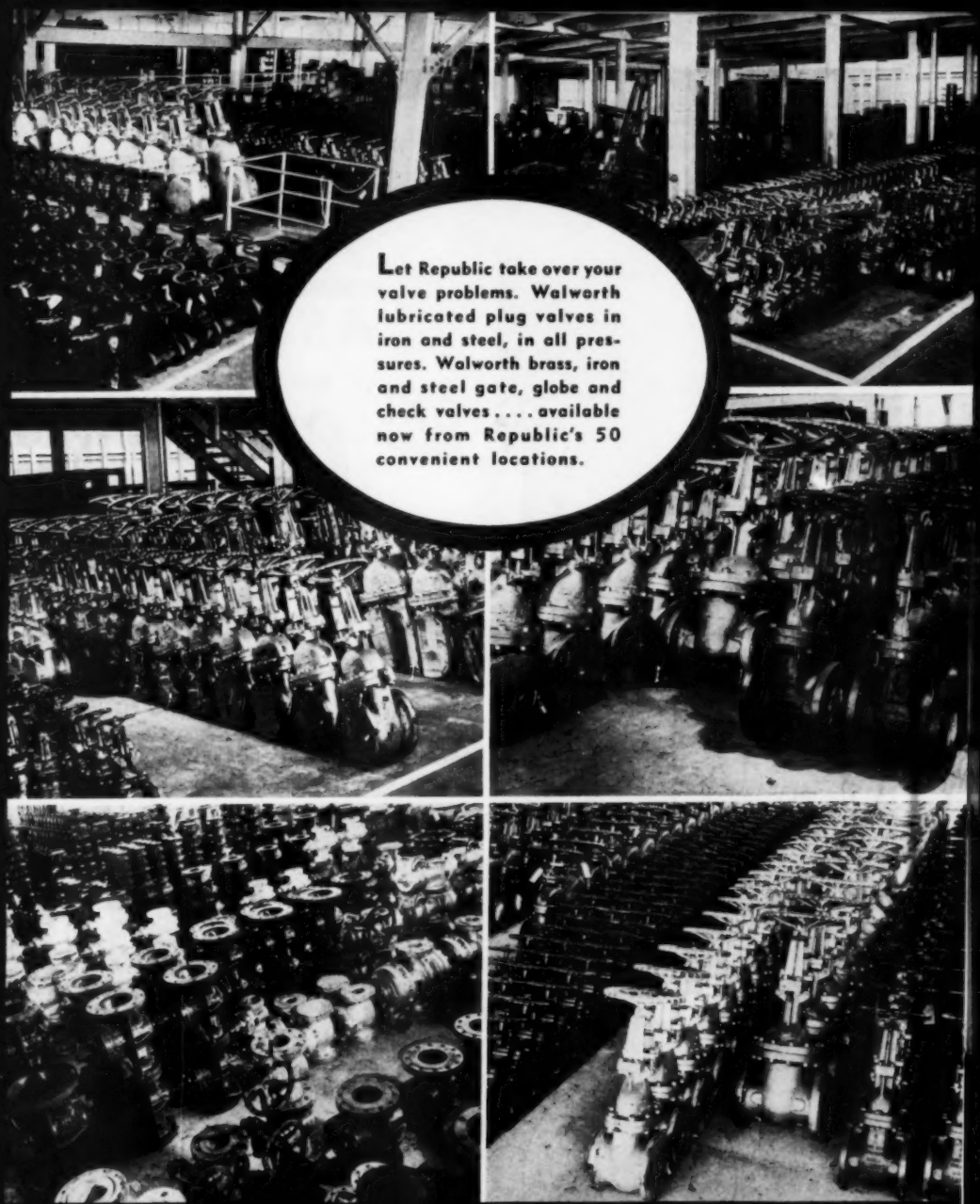

Let Republic take over your valve problems. Walworth lubricated plug valves in iron and steel, in all pressures. Walworth brass, iron and steel gate, globe and check valves . . . . available now from Republic's 50 convenient locations.

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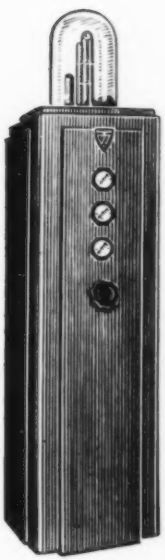
YOUR SUPPLY R STORE

A
COMPLETE
Packaged
ASSEMBLY
ONLY 2 CONNECTIONS TO MAKE
Operating Medium
Supply Connection
FISHER
DIAPHRAGM
MOTOR VALVE
FISHER GOVERNOR COMPANY
MARSHALLTOWN, IOWA

APARTMENT FOR SLIME

With condenser tubes handling unchlorinated water, slime-forming bacteria never have to worry about a housing shortage. Instead, these bacteria move in, form their colonies, and the condenser tubes become apartments for slime. When this happens, the terminal log mean temperature difference rises, excess steam costs go up, and outage increases along with the labor bill for costly plug cleaning.

Chlorination, engineered by W&T and backed by 35 years' experience, has proven itself the effective answer to slime in condenser and heat exchanging equipment. It is effective because the Wallace & Tiernan De-Sliming Process attacks the cause of slime, bacteria, and "evicts" these unwanted "tenants" from their home in your equipment.



CD-32

Regardless of whether yours is an open or closed cooling system or whether you use shell and tube, trombone, or open box condensers, Wallace & Tiernan engineering plus time-tested W&T Chlorinators can put all the money-saving advantages of slime control by chlorination to work on your condensers or heat exchange equipment.

Write today for complete information.

WALLACE & TIERNAN
PRODUCTS, INC.

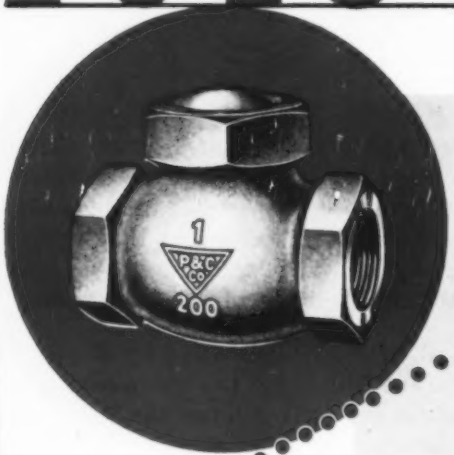
CHLORINE AND CHEMICAL CONTROL EQUIPMENT

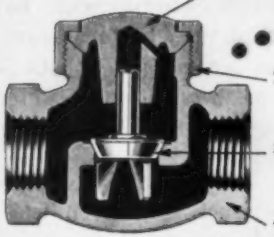
Belleville 9, New Jersey • Represented in Principal Cities

R·P&C

BRONZE LIFT CHECK VALVES

designed and built to take ***PUNISHMENT***





1 CAP—forms an efficient beveled joint with the body. The integral disc guide has long contact with the disc stem for perfect alignment and resulting free movement and positive seating. It also cushions disc movement.

2 UNION NUT—heavy and rugged. Can be removed and replaced without danger of distorting the body or weakening threads.

3 DISC—well guided with just the right seating angle for positive closure without sticking. Seating surfaces regrindable.

4 BODY—has heavy section at cap joint and end hex with long contact end threads. Seat is integral with body.

THESE BRONZE LIFT CHECKS—rated 200 pounds and 300 pounds—are especially suited to prevent back-flow on high velocity line or where flow is pulsating. Shut-off is quick, positive and tight. For use in horizontal lines only. • (On low or moderate velocity lines, R-P&C swing checks are recommended.) • Get in touch with the nearest R-P&C District Office or R-P&C Distributor for information about Check Valves.

ACCO

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R-P & C VALVE DIVISION
AMERICAN CHAIN & CABLE

TRADE MARK

READING-PRATT & CADY VALVES

Launched . . .

. . . for shore duty

Besides having the know-how and facilities for fabricating every kind of refinery and chemical plant equipment, Sun is ideally located. Sun-built units such as this tower, too large to be shipped by rail, can be transported by water—floated or carried as deck loads or on barges . . . Here, too, on the deep Delaware River, Sun builds its famous tankers and cargo vessels.

Sun

SHIPBUILDING & DRY DOCK COMPANY

SINCE 1916

ON THE DELAWARE • CHESTER, PA.

25 BROADWAY • NEW YORK CITY

new BJ vertical circulating pumps

Complete and brand new line of single and multi-stage turbine type pumps for cooling towers, irrigation, dewatering, river-intake, and drainage.

RUN THEM DAY AND NIGHT. These new BJ Pumps have the inside construction you need for continuous low cost operation. They are designed with strength for dependability. And for day and night operation, the BJ calibre of performance means a great deal.

THESE ARE NEW PUMPS, products of the latest thinking in hydraulics. They are backed by three-quarters of a century of experience in designing superior centrifugal pumps. BJ's new Vertical Circulating Pumps have the stamina, the "built-to-last" qualities for which all BJ Pumps are famous. An illustrated bulletin describing these pumps is already printed... no delay... so write today for further information on how these pumps can help you.

Consider These Primary Advantages

minimum foundation requirements

remote control

simple fabrication... easy maintenance

your piping plans simplified

vertical installation saves you space

pumping efficiencies determined in BJ's new hydraulic laboratory.

Byron Jackson Co.

Since 1872

LOS ANGELES 54, CALIFORNIA

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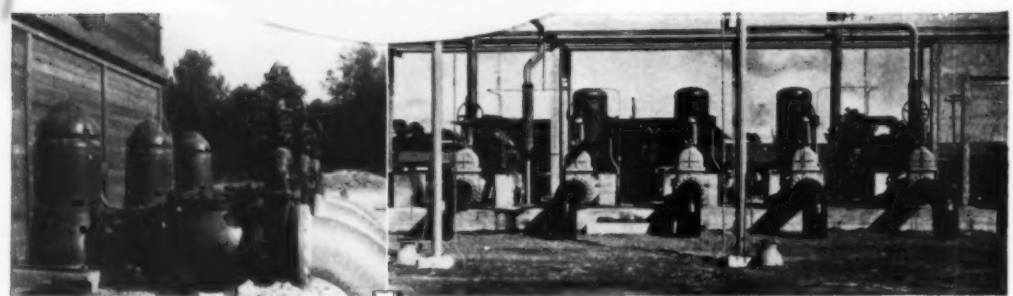


USING 3 PUMPS PER STATION. Seven stations of a large gas transmission line are equipped with BJ Vertical Circulation Pumps. Each of the 21 pumps delivers 4500 gpm against a total dynamic head of 42 feet.

THESE PUMPS are self-priming. Suspended vertically, they are self-contained pumping units taking suction from the pit in which they are mounted.

USE MOTORS OR TURBINES AS DRIVERS in Cooling Tower Service. Each pump delivers 7500 gpm against 118 ft. head and operates at 1200 rpm. Three center pumps are direct-connected to explosion-proof motors. Two outer pumps are driven through reduction gears by 3600 rpm steam turbines.

LEAD VALVES

Control Hungry Acids

Chem Rayon "Y" Pattern

Type C "Y" Pattern

Men who need to tame biting acids and put them to useful work have long relied on lead. And they look to the leader in lead . . . National Lead Company . . . for dependable lead and lead-lined acid valves.

National Lead's "United" valves work efficiently at their routine jobs of controlling the flow of corrosive acids. But they also have the built-in stamina and sturdiness to withstand stresses and overloads well beyond their regular lines of duty.

Wedge Type Gate Pattern

The "United" valve you buy is representative not only of National Lead's resources in the lead products manufacturing field but also of resourcefulness in designing acid valves that make the most of lead's inherent corrosion-resistant properties.

Type D Check

Chem Rayon Angle Pattern

Under the name "United," National Lead Company offers a complete line of hard lead and lead-lined flanged acid valves —"Y" and angle patterns, gate, check, foot and diaphragm.

Diaphragm Pattern

Type R Reversible-Angle or "Y"

Look to the Leader for Lead

. . . in everything from lead pipe . . . valves . . . sheet . . . and lead-lined or lead-covered equipment . . . to complete acid recovery plants.

NATIONAL Lead Company

New York 6; Baltimore 3; Buffalo 3; Chicago 8; Cincinnati 3; Cleveland 13; Pittsburgh 12; St. Louis 1; Boston 6, (National Lead Company of Mass.); Los Angeles 23, (Morris P. Kirk & Son, Inc.); Philadelphia 25, (John T. Lewis & Bros. Co.); Atlanta (Georgia Lead Works, Div. of Cincinnati Branch); Toronto, Canada (Canada Metal Co. Ltd.).

For Extremely Low Hydrogen Content Weld Deposits

with no under bead cracking, minimum porosity, low spatter loss and ample penetration

No. 312 Electrode for Mild Steel (E-6016)
No. 394 Electrode for High Tensile Steel of High Hardenability (E-10016)

Due to the extremely low hydrogen content of the weld deposits, Airco No. 312 (all position A-C or D-C) is especially recommended for welding hard-to-weld steels (without preheating) such as hardenable steels . . . high sulphur free machining steels . . . cold rolled steels . . . low alloy or mild steels where stress relieving cannot be employed . . . and steels to be vitreous enamelled after welding.

Airco No. 394 (all position A-C or D-C) provides low hydrogen content weld metal deposits of *high tensile strength* on hardenable steels without pre-heat or post-heat treatment. It is also used on carbon steel containing 0.30% or more carbon and should be used on steel containing alloying elements in addition to a high carbon content.

For more information about Airco Nos. 312 and 394 Electrodes, write your name and address on the margin below and send it to your nearest Airco office or authorized dealer for a copy of Catalog ADC-650A.

More news about AIRCO products

NO. 387 ELECTRODE (E-6012)

A high speed all position electrode (D-C or A-C) — ideal for welding mild steel when fit-up is poor. It exhibits excellent operating characteristics, particularly when welding vertically down, and produces a minimum of spatter. Airco No. 387 maintains a high degree of welding performance throughout the entire length of the electrode when high currents are used.

NO. 375 ELECTRODE

Specifically designed for producing machinable welds in cast iron. Deposits are smooth and uniform, bonding well with the cast material; free from internal and surface porosity; and make water-tight joints. Also, color of deposits will approximate that of cast iron. No. 375 can be used in all positions with A-C or D-C.

NO. 230 ELECTRODE (G6011)

This all-position electrode is designed for AC or DC reversed polarity welding of mild steel. Its specially formulated coating produces a spray type arc. The strong arc force, and rapid solidification of the weld metal permits maintenance of high welding speed, particularly in the vertical and overhead positions.

★ ★ ★

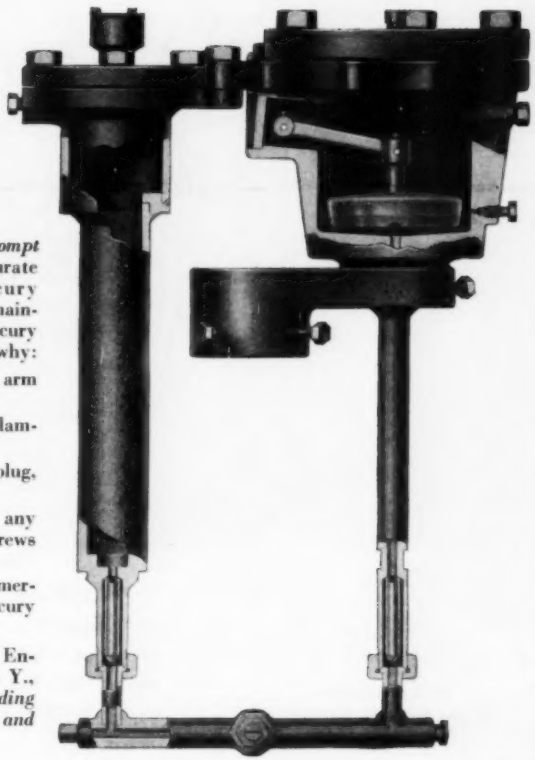
Magnolia Airco supplies Oxygen, Acetylene and other industrial gases . . . Carbide . . . and a complete line of gas cutting machines, gas welding apparatus and supplies, plus arc welders, electrodes and accessories. Ask us about anything pertaining to gas welding and cutting, and arc welding . . . we'll be glad to help you.

MAGNOLIA AIRCO GAS PRODUCTS CO.

Houston • Beaumont • Corpus Christi • Wichita Falls
El Paso • Fort Worth • San Antonio • Dallas

New Taylor Mercury Manometer is

MAINTENANCE MAN'S DREAM!



Now you can have *prompt* delivery on this accurate new Taylor 1500 Mercury Manometer. It's easier to maintain than any other mercury manometer—and here's why:

(a) ***Easy to calibrate*** by reaching float and lever arm through top of pressure chamber.

(b) ***Easy to replace*** pressure-tight bearing without damage if ever required.

(c) ***Easy to fill***—vent valves in cover, mercury level plug, built-in mercury funnel, bull's eye level.

(d) ***It's easy to fit*** Manometer on pipe support in any position—and in accurate alignment—thanks to set screws instead of threads.

(e) ***And to change range*** you simply: **(1)** Drain mercury, **(2)** Take out old range tube, **(3)** Fill with mercury to sight level, **(4)** Re-zero.

Write for Bulletin 98182, or ask your Taylor Field Engineer. Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada. *Instruments for indicating, recording and controlling temperature, pressure, humidity, flow and liquid level.*

QUICK FACTS FOR THE ENGINEER

1. ***High Accuracy***—Inherent straight line calibration.

2. ***Floating Power***—great power made possible by large float and long travel, transmitted by non-corroding "Teflon" bearing which "floats" power through to the pen.

3. ***Positive Actuation***—High energy output. **(a)** ***Big 3¼" float.*** **(b)** ***Long travel of float—1".*** **(c)** ***Simple lever system.*** Stainless steel lever arm fastened to flat of pressure-tight bearing shaft with screw. **(d)** ***Teflon in pressure-tight bearing surfaces*** assures efficient use of power because; Teflon bearing, micro-finished shaft, silicone lubricant give unprecedented performance—leakless, and negligible friction under high working pressures. Union coupling on bearing housing prevents distortion of bearing and binding of shaft. **(e)** ***Jewelled thrust bearing.***

4. ***"Dependable Performance"*** **(a)** ***Submerged check valves.*** **(b)** ***Unique damping valve*** easily adjusted under full pressure without leakage. **(c)** ***Ample capacity*** in mercury chambers to accommodate effects of surges or pulsating flows. **(d)** ***Teflon holds pressure,*** yet allows shaft to rotate freely and assure long, dependable service.

5. ***"Great Adaptability"*** **(a)** ***Six interchangeable range tubes:*** 10", 20", 50", 100", 200", and 400" of water. **(b)** ***Tubes can be easily changed*** in field without piping alterations.

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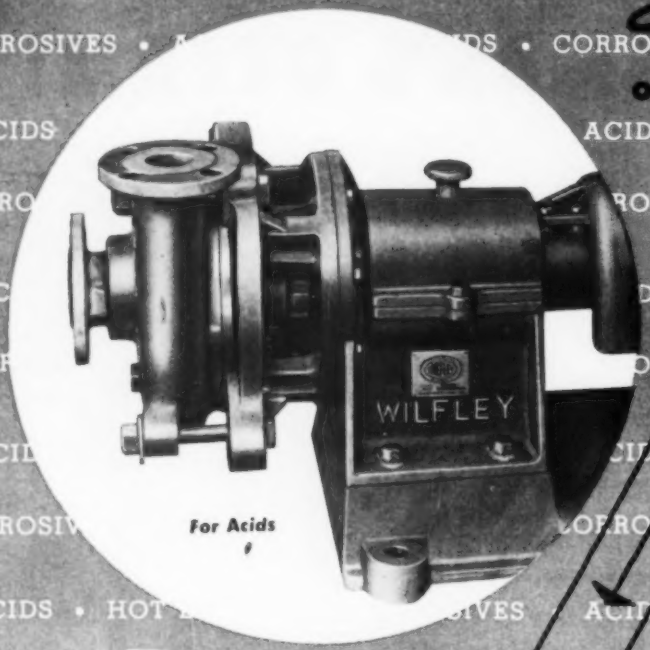

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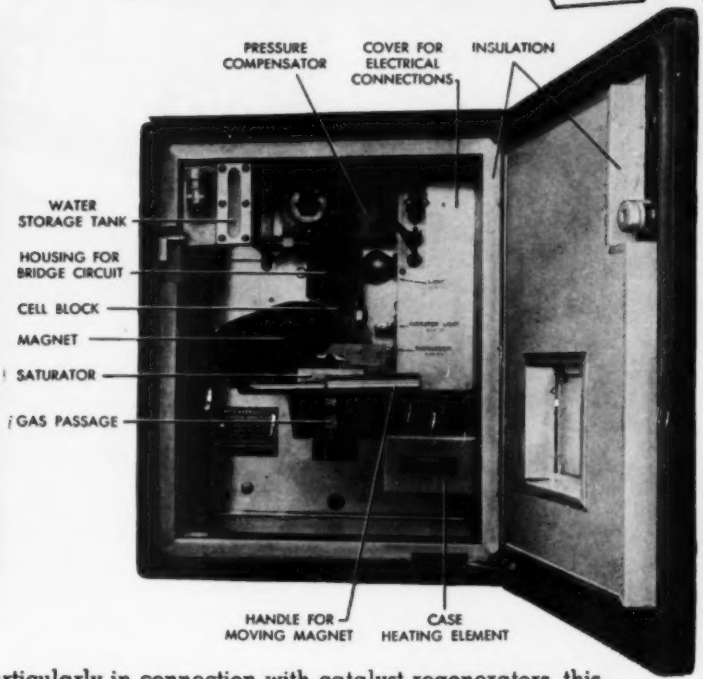
The HAYS MAGNO-THERM OXYGEN ANALYZER



Particularly in connection with catalyst regenerators, this Oxygen Meter has been tested and proved in service to measure oxygen with sustained accuracy and dependability.

Operates on an entirely new principle based on the paramagnetic property of oxygen. No combustion required—no fuel has to be added. Temperature of gas analyzing cell is too low to support combustion, which is a strong safety feature.

One large refinery superintendent says, "After testing several oxygen meters, we find the Hays meter to be operating on the best principle. We like its simplicity, its design, its method of operation, and its rugged construction."

The interesting story of the Hays Oxygen Meter, including the electronic type recorder, is told in Bulletin 48-829. Write for it today.

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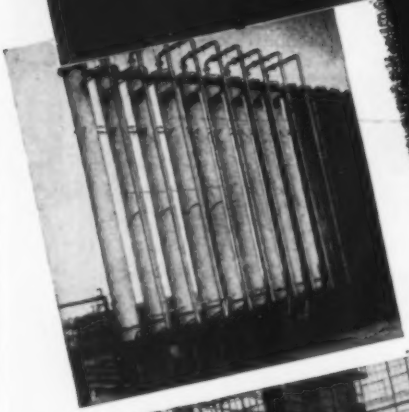

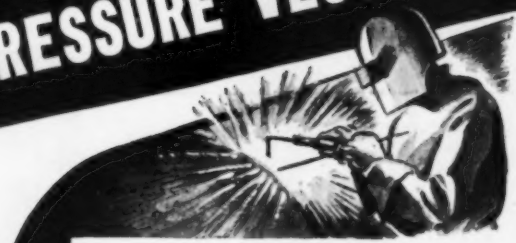

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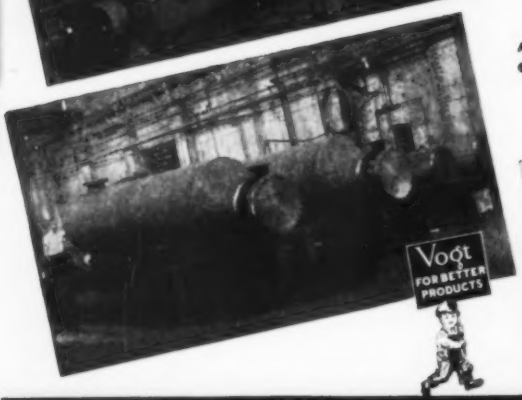

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Trim is solid Stellite. The retained seat is type No. 12 and the plug is type No. 6 Stellite. The spline plug has a valve lift of 1", from the closed to the wide open position. Rangeability 50:1, or better, in all fifteen plugs. Equal percentage flow characteristics sizes No. 1 thru No. 5. Linear flow sizes No. 6 thru No. 15. Spline plug is a selective fit in a honed seat.

* The valve flow coefficient "Cv max." at one inch of lift, is equal to the rate of flow in GPM of water (or equivalent "cc") at one psi pressure drop across the valve body. The minimum flow will be 1/50 of Cv max., shown in the table.

* CONVERSION OF FLOW COEFFICIENT C= TO CUBIC CENTIMETERS

Valve Size	Cv	CC
1	0.63	2385
2	0.40	1514
3	0.25	946
4	0.16	605
5	0.10	378
6	0.063	238.5
7	0.040	151.4
8	0.025	94.6
9	0.016	60.5
10	0.010	37.8
11	0.0063	23.85
12	0.0040	15.14
13	0.0025	9.46
14	0.0016	6.05
15	0.0010	3.78

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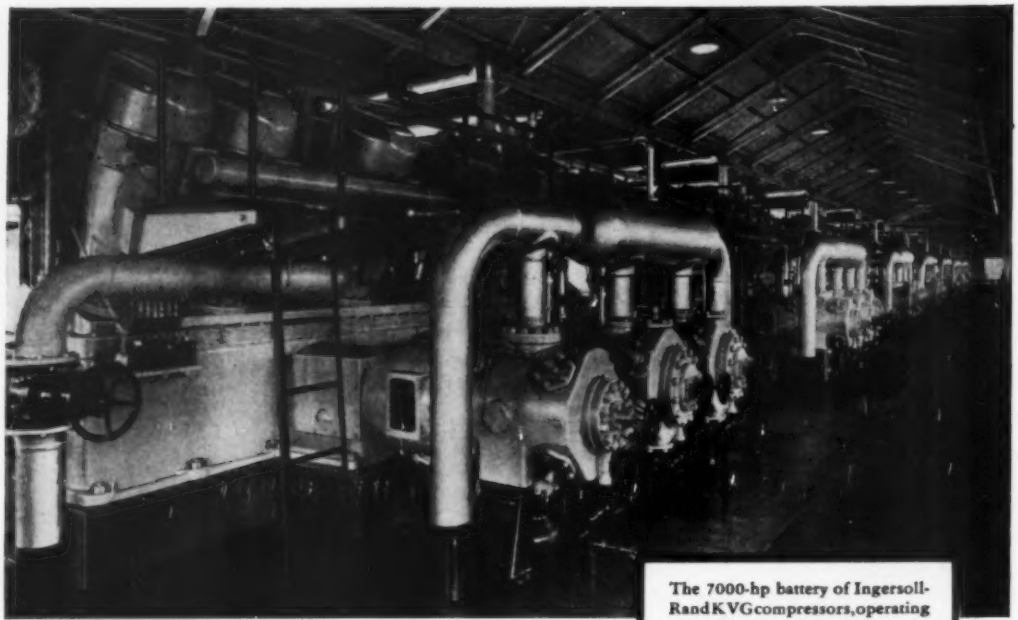
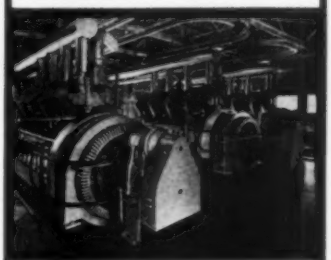


The 7000-hp battery of Ingersoll-Rand KVG compressors, operating 35 to 65 psig intake, 700 to 810 psig discharge, at the Anahuac extraction plant of a large oil company.

In the Anahuac gasoline-extraction plant of a large oil company these 7 Ingersoll-Rand 1000-hp KVG gas-engine-driven compressors gather and compress casinghead gas from producing oil wells. The gas is "stripped" of its liquid content, and the high-pressure residue gas is distributed by pipe line to various industrial centers where it is fully utilized. This is a typical phase of a 17-year old *gas-conservation program* that you in the Petroleum Industry have been waging with increasing determination and success.

The compressors, as well as the gas-engine-generator units (right) in the same plant, are of Ingersoll-Rand 4-Cycle V-design. This design is not new to the oil company's engineers. They have been using 4-Cycle V-compressors and gas engines in various services during a 12-year period.

No matter what your load, pressures, or speed, Ingersoll-Rand 4-Cycle Vees are the logical choice for *dependability, economy,* and *operating flexibility* . . . in refinery, cycling, repressuring and pipe-line services.



Three I-R 370-hp Type PVG gas-engine-generator units installed in the same plant.

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So, whether you're making a new installation or need replacements, be sure to specify Powell Valves. And remember Powell Engineering Service is always at your disposal in selecting the correct valves to meet your individual requirements.

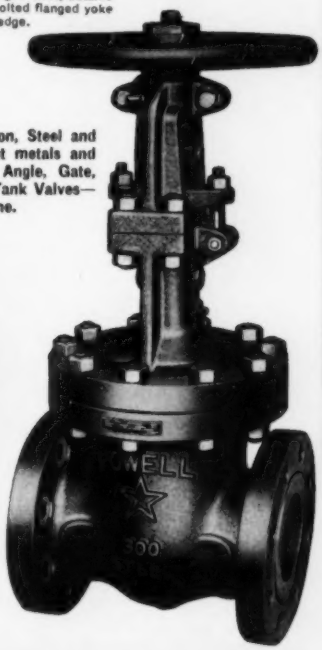
Fig. 3003—Class 300-pound Cast Steel Gate Valve with flanged ends, outside screw rising stem, bolted flanged yoke and tapered solid wedge.

Fig. 375 — 200-pound Bronze Gate Valve. Screwed ends, union bonnet, inside screw rising stem and renewable "Powellium" wear-resisting nickel-bronze disc.

Fig. 1708 — 200-pound Bronze Globe Valve with screwed ends, union bonnet, renewable, specially heat treated stainless steel seat and regrindable, renewable wear-resisting "Powellium" nickel-bronze disc.

Powell Valves are made in Bronze, Iron, Steel and a wide selection of Corrosion-Resistant metals and alloys. Valves of every type—Globe, Angle, Gate, Check, Non-return and Flush Bottom Tank Valves—are included in the Complete Powell Line.

Fig. 559—125-pound Iron Body Bronze Mounted Swing Check Valve. Flanged ends, bolted flanged cap and regrindable, renewable bronze seat and disc. Disc, when wide open, permits full, unobstructed flow through valve body



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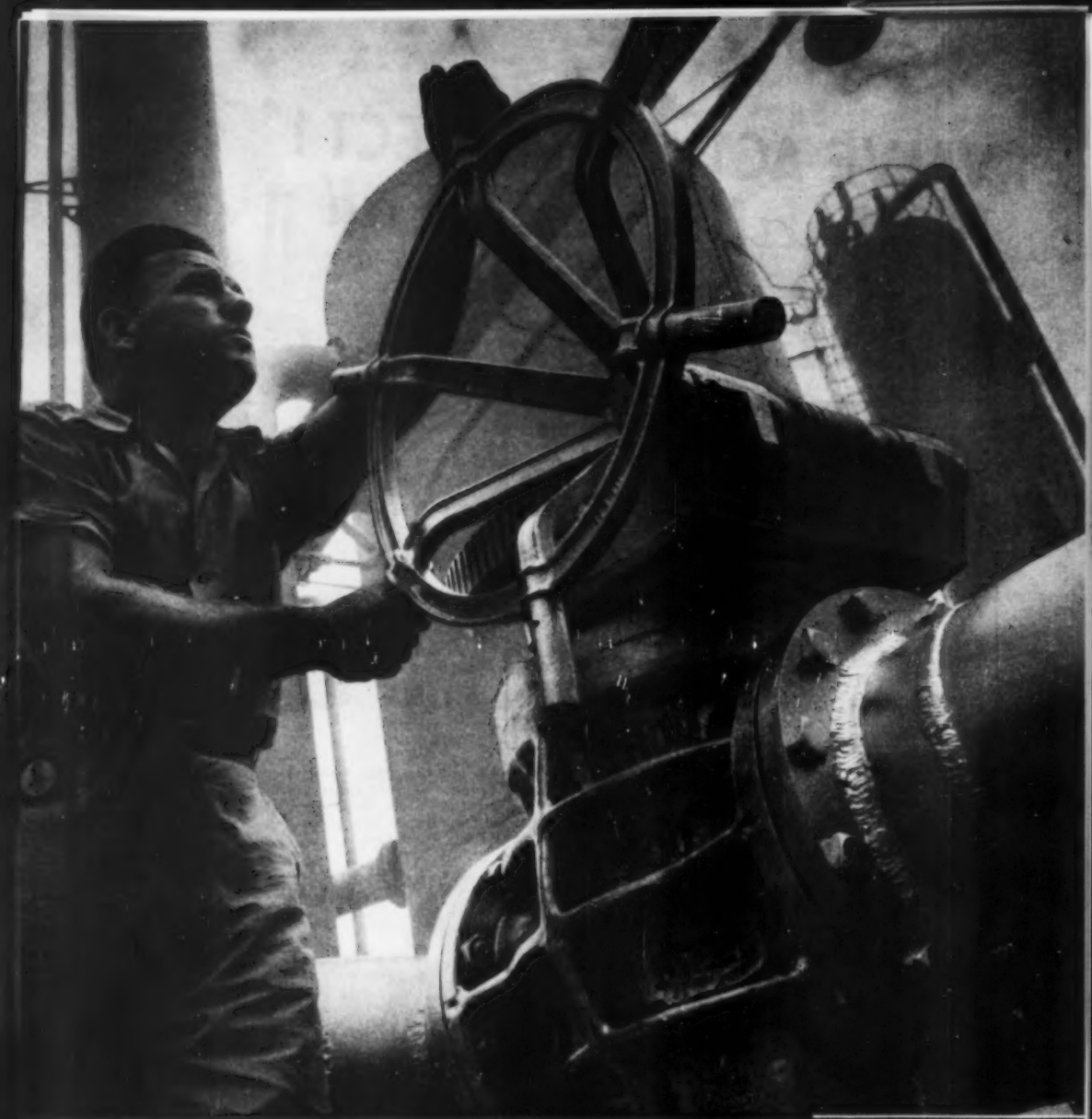

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When you operate a Nordstrom valve you don't have to battle with it. Simple slideable rotary action replaces wedging, jamming and forcing. You can open or close a Nordstrom in a matter of seconds. You don't have to guess whether or not the valve is seated—it's always seated. The effective life of Nordstrom valves is so extended that they cost less in point of service rendered—a fact proved by any comparison.

KEEP UPKEEP DOWN—*Use only genuine Nordstrom lubricants*

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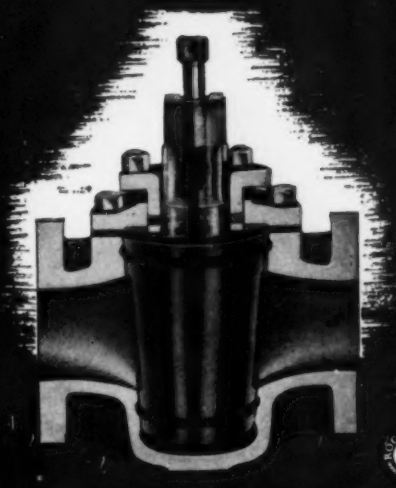
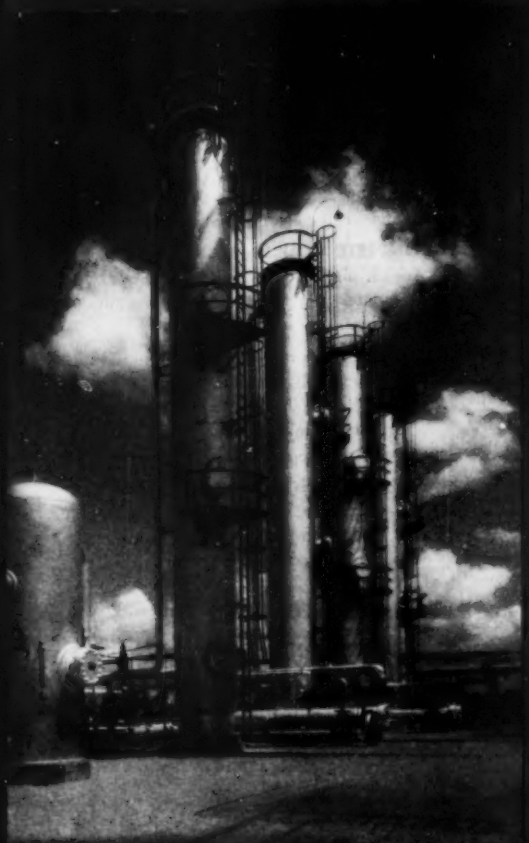
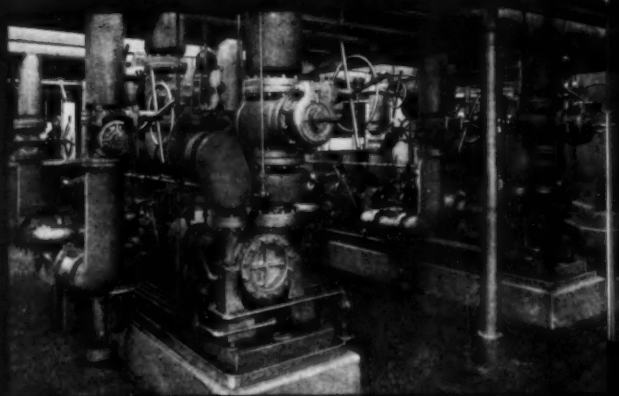
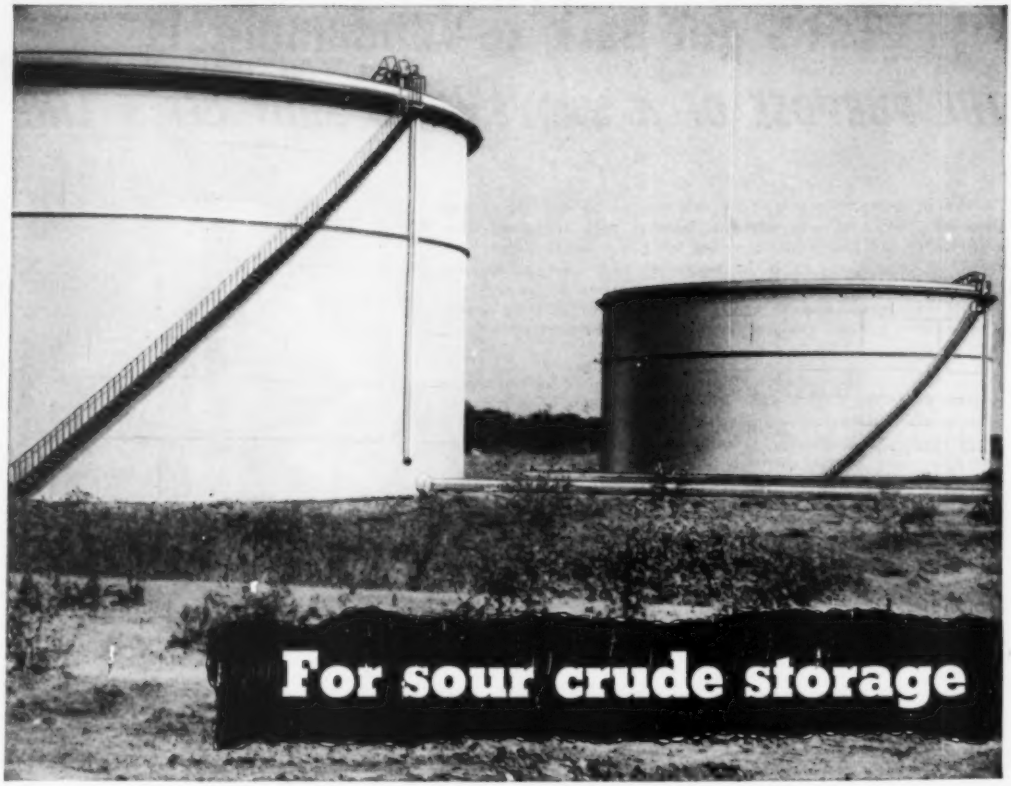




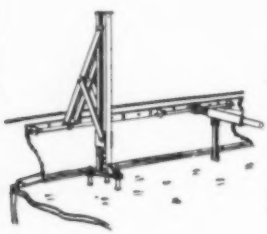


All lines for all purposes

Nordstrom



END CORROSION—END FILLING LOSSES



Corrosion and filling losses . . . these are the problems that complicate the storage of sour crude. To meet these problems efficiently and economically, Graver offers an improved Floating Roof with Full Double Deck. Check these advantages:

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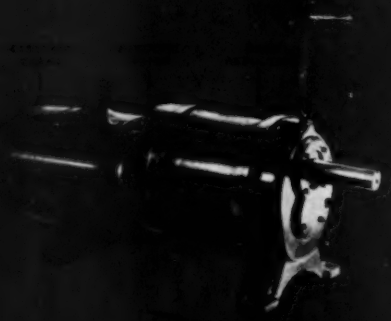

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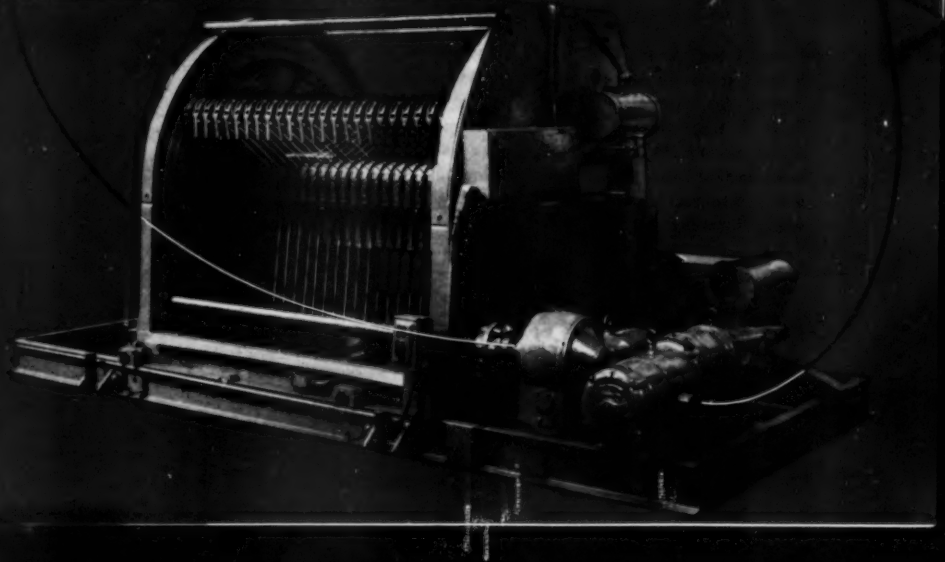

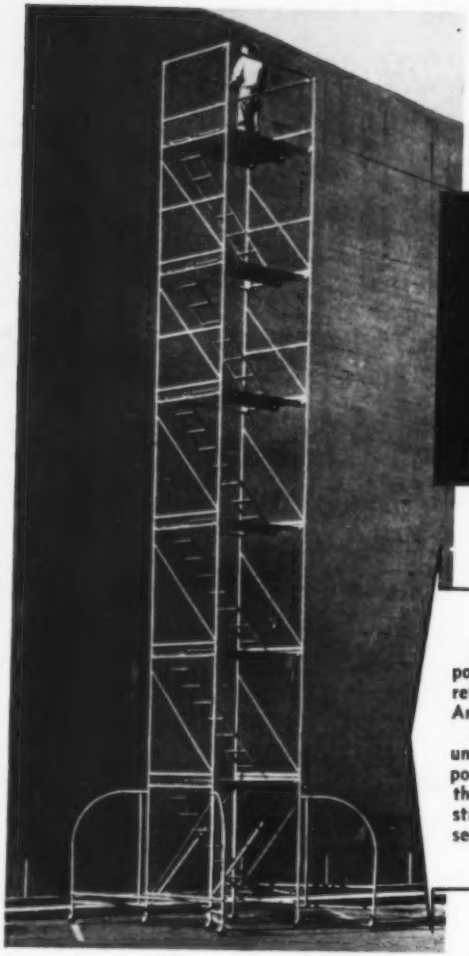

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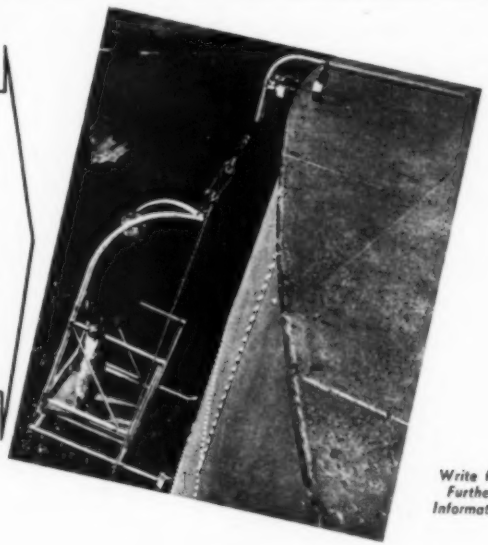

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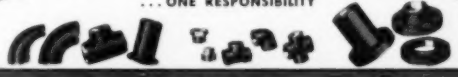

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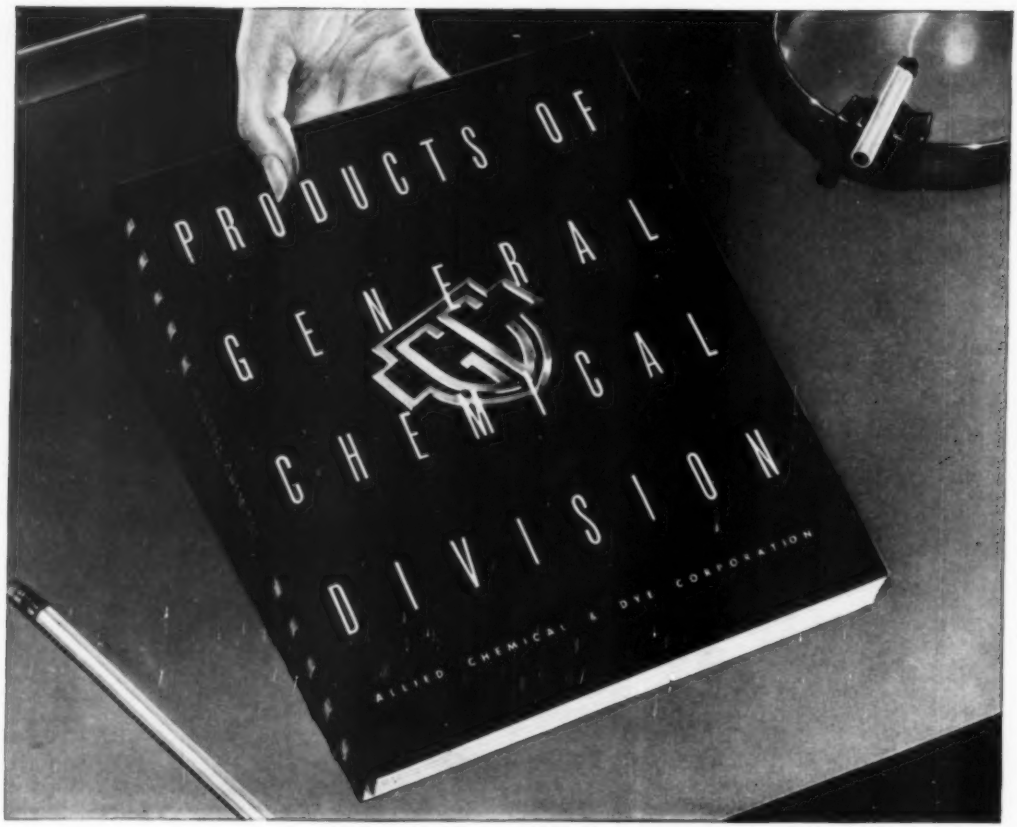

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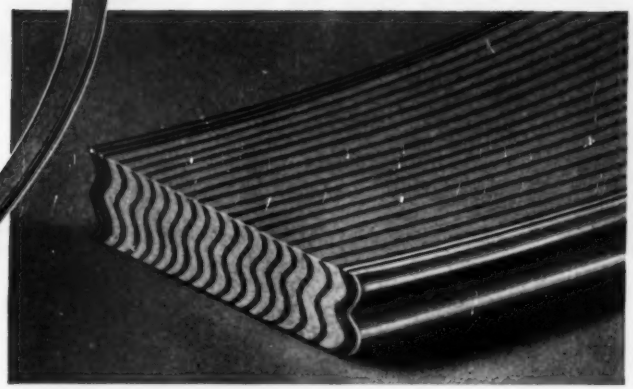

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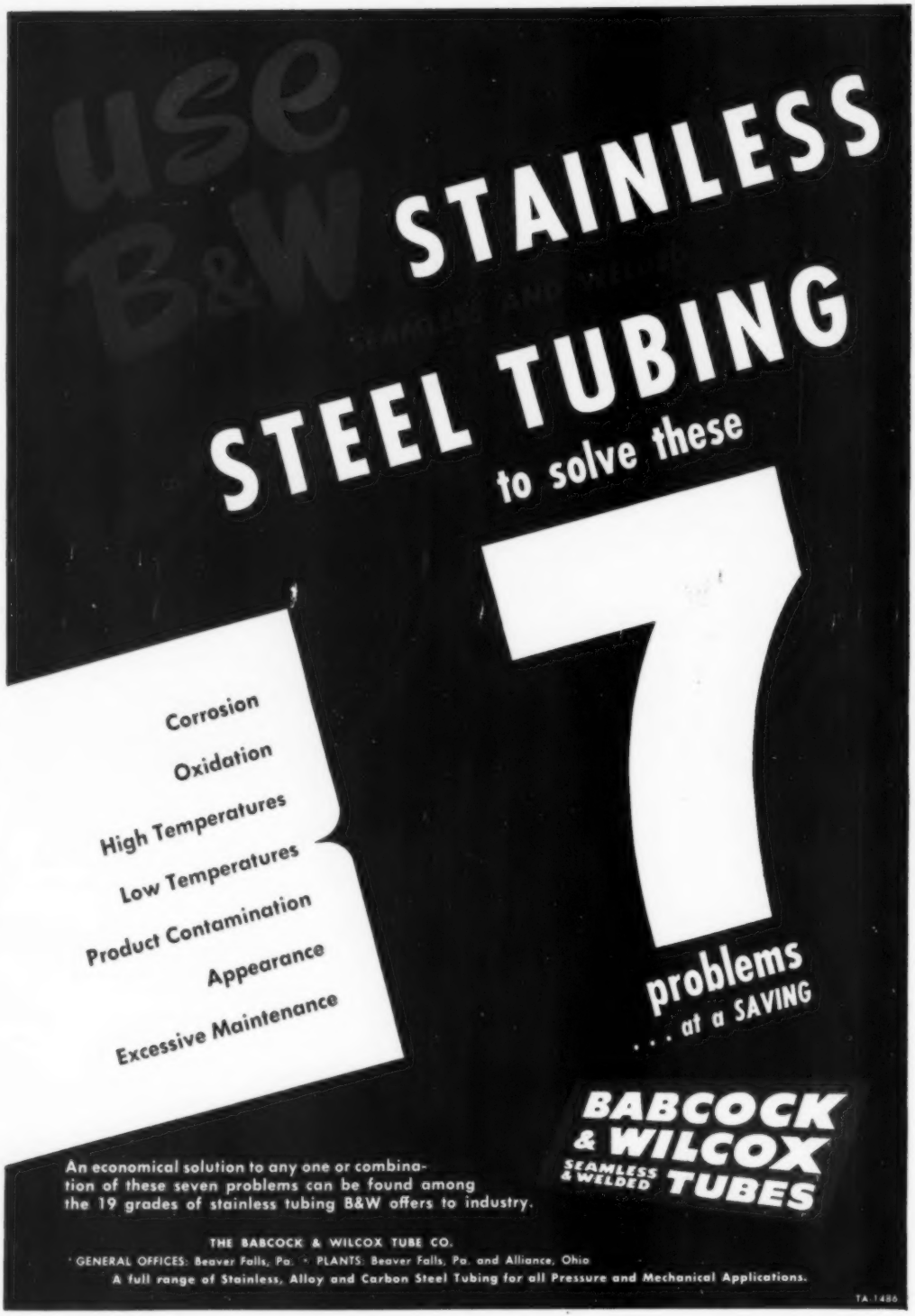
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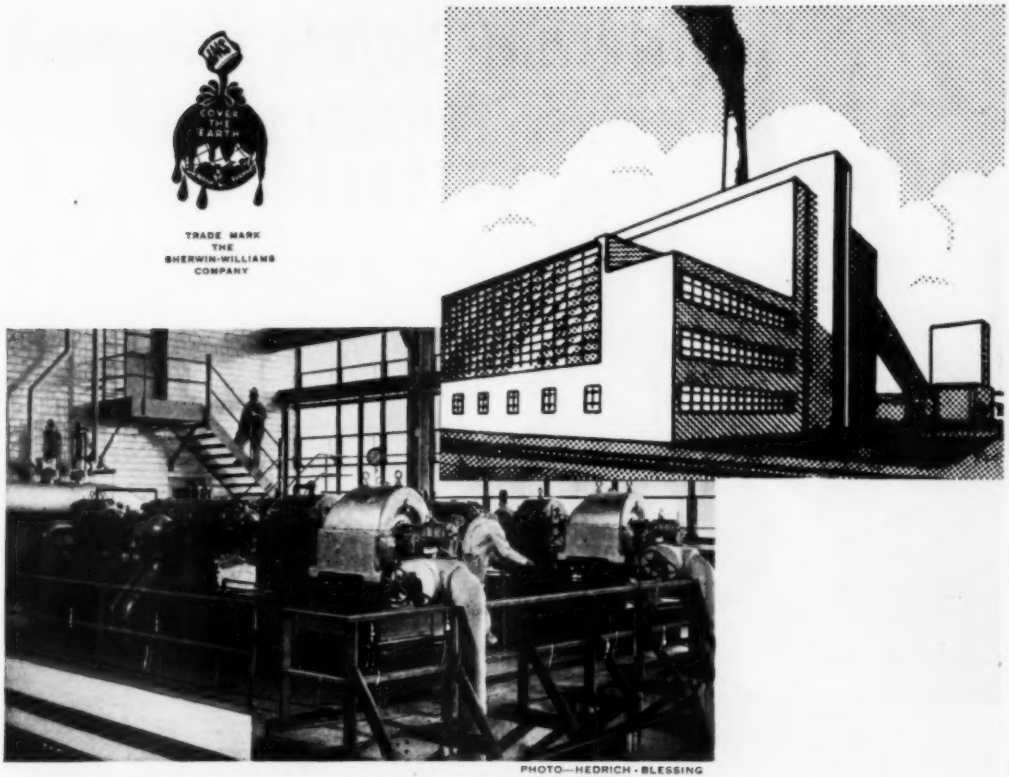


PHOTO—HEDRICH · BLESSING

TRADE MARK
THE
SHERWIN-WILLIAMS
COMPANY

SHERWIN-WILLIAMS INSTALLS FULLER ROTARY COMPRESSORS IN NEW BOILER HOUSE

Long delayed, due to difficulties encountered in obtaining materials and equipment during the war years, the much needed new boiler house of The Sherwin-Williams Company Chicago plant, was put into operation during the early part of 1947. However, this delay permitted further study and adoption of the latest techniques, and several unique dividend-paying features.

Fuller Company is justly proud to have been given the opportunity to supply two "lifetime-efficient" Fuller Rotary Compressors for this most modern and efficient industrial plant. These compressors are of the two-stage type, each having a capacity of 1592 c.f.m., free-air, at 120-lb. pressure, driven by 350 hp. turbines, equipped with speed reducer, to operate at 575 r.p.m. They furnish air for both factory and power house service.

Bulletin C-5, illustrates and describes Fuller Rotary Compressors and Vacuum Pumps. We'll be glad to send you a copy.

FULLER COMPANY, CATASAUQUA, PA.

Chicago 3 · 120 So. LaSalle St.

San Francisco 4 · 420 Chancery Bldg.

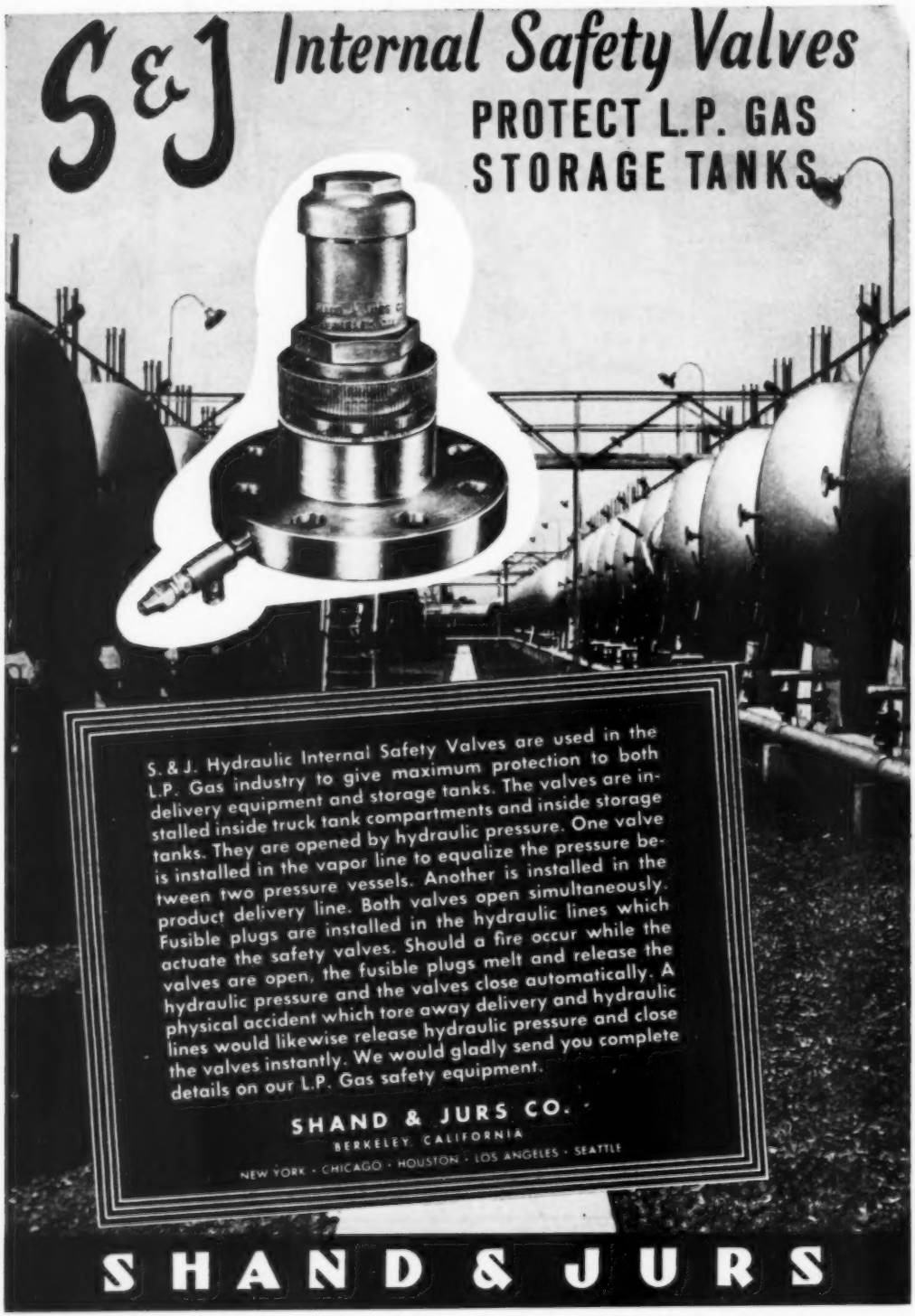
A LIFETIME OF NEW MACHINE EFFICIENCY

FULLER

C-179

S&J Internal Safety Valves

PROTECT L.P. GAS STORAGE TANKS



S. & J. Hydraulic Internal Safety Valves are used in the L.P. Gas industry to give maximum protection to both delivery equipment and storage tanks. The valves are installed inside truck tank compartments and inside storage tanks. They are opened by hydraulic pressure. One valve is installed in the vapor line to equalize the pressure between two pressure vessels. Another is installed in the product delivery line. Both valves open simultaneously. Fusible plugs are installed in the hydraulic lines which actuate the safety valves. Should a fire occur while the valves are open, the fusible plugs melt and release the hydraulic pressure and the valves close automatically. A physical accident which tore away delivery and hydraulic lines would likewise release hydraulic pressure and close the valves instantly. We would gladly send you complete details on our L.P. Gas safety equipment.

SHAND & JURS CO.
BERKELEY, CALIFORNIA
NEW YORK · CHICAGO · HOUSTON · LOS ANGELES · SEATTLE

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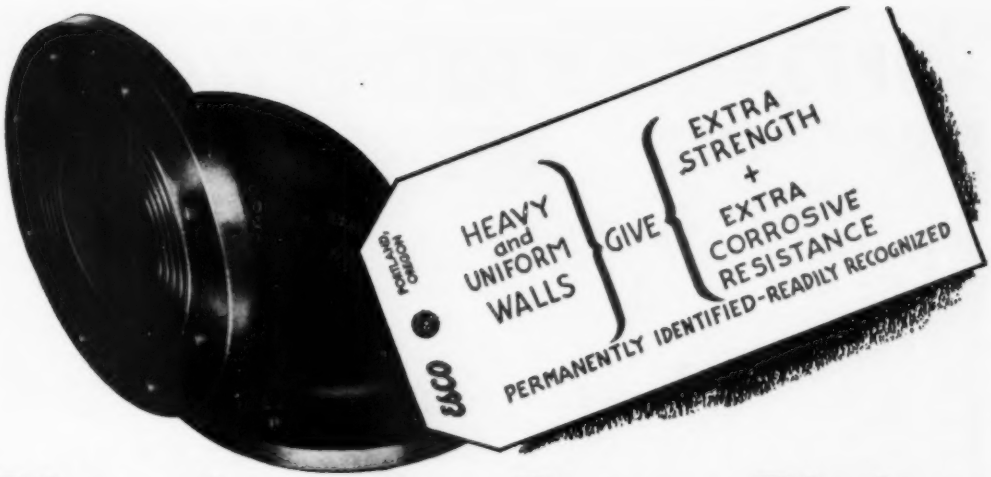

Directions for Better Piping

A Complete Story in 58 Words

The two-sided tag reproduced here tells the story of *ESCO* stainless steel corrosion-resisting pipe fittings with only 58 words. For details of sizes and dimensions let us send you our Fittings catalog 165Ar.

ESCO

STAINLESS and HIGH ALLOY STEELS

FOR THE PROCESS INDUSTRIES

Fill in and mail the coupon. Electric Steel Foundry, 2181 N.W. 25th Avenue, Portland 10, Oregon. Offices in Eugene, Oregon; Chicago; Honolulu; Houston; Los Angeles; New York City; San Francisco; Seattle; Spokane. In Canada, *ESCO* Limited, Vancouver, B.C.

ELECTRIC STEEL FOUNDRY
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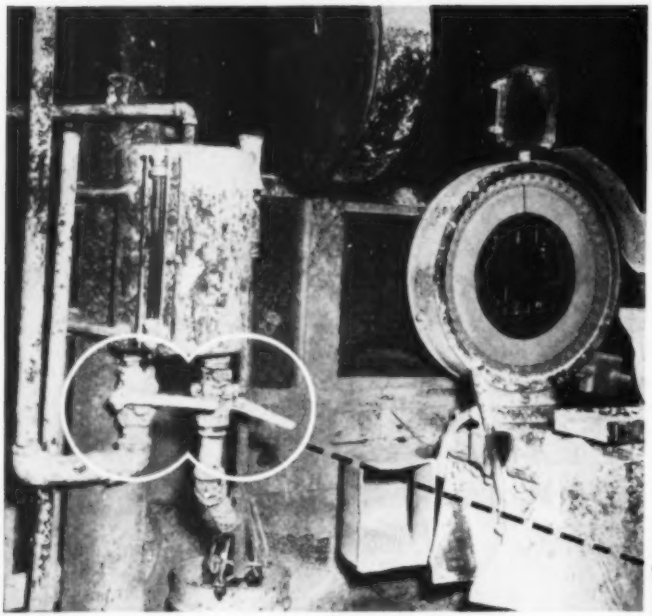
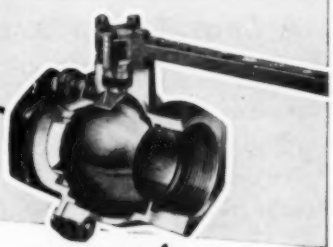
OPERATED *350,000 TIMES!* with NO MAINTENANCE



Libbey-Owens-Ford Glass Company obtains outstanding results with

ROCKWOOD BALL VALVES

Only Valve to Stay in Service Over a Year



Here, in this glass plant, Rockwood Ball Valves are giving *unsurpassed* service under extreme rugged conditions. For over a year, they have been opened and closed over and over again without the need of maintenance.

The two 1½" Rockwood Valves shown above are used on river water to mix plaster for the Grinding and Polishing line. Both Valves are worked 24 hours a day, 5 to 6 days a week and are operated approximately 1500 times a day depending on line speed. Company official says, "We are very well pleased with their operation; the best service we could get from other makes of valves prior to this was 6 to 8 weeks."

This plant is only one of many that is getting outstanding results from Rockwood Ball Valves. Place your order today for the new Rockwood Ball Valve.

For additional information and uses, write for bulletin V-4 today.

FULL ROUND FLOW! LEAK PROOF SERVICE!

To ensure top performance, Rockwood engineers designed the Rockwood Ball Valve with these 7 outstanding features. 1. Full round open area — no turbulence in fluid stream. 2. Leak proof after continued use. 3. Floating ball — resists pitting, scratching and abrasion. 4. No exposed seating surface in open or closed position. 5. Easy to open or close under full pressure. 6. Installed in any position. 7. Quarter turn (90°) opening and closing valve.

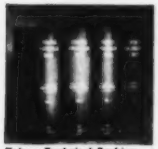
Rockwood Ball Valves are available in bronze from ½" to 2" for 300 p.s.i. working pressure and are recommended for use on lines handling water, air, gas, petroleums, food, carbon dioxide, nitrogen, paraffin and asphalt base petroleums, also alcohol, paper fluids and other types of liquids and gases.

Distributors in all principal cities.

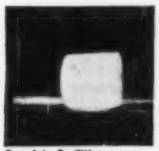
ROCKWOOD SPRINKLER CO

102 HARLOW STREET WORCESTER 5, MASS

Metallurgical Research conducted continually by recognized specialists who have made major contributions in this field.



Unique Technical Backing of an extensive organization with an international reputation in both process and fabrication engineering.

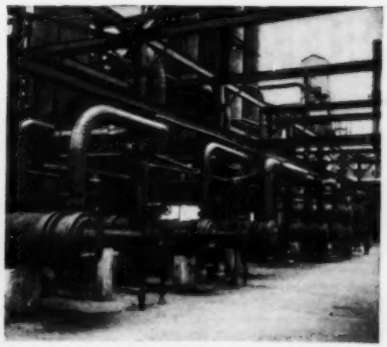


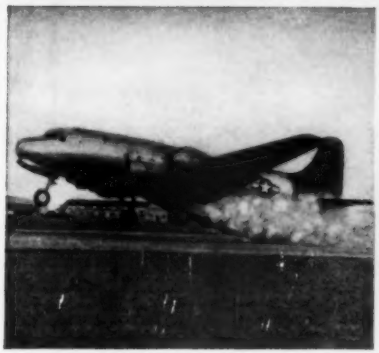
Complete Facilities for the fabrication of steel products from simple forgings to the most intricate 120 foot towers.

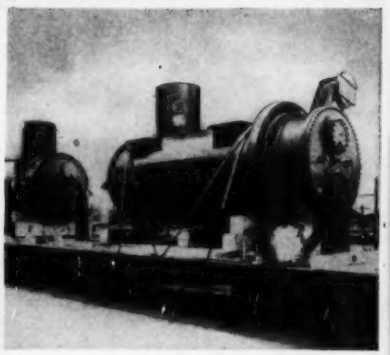
Top Welding Performance assured by specially designed equipment and exclusive employment of master operators.

Quality Control embracing the constant application of the most advanced inspection methods, both visual and non-destructive.

On-Time Delivery made possible by a flexible planning group authorized to re-route work to meet promised dates.







What do these four have in common?

IT is the common denominator of this broad grouping that means something to you—the problem of heat exchange under varying conditions.

Take the Oak Ridge job. It was colossal in size and concept. But it was also outstanding because it included both processing of one of the most corrosive agents known (uranium hexafluoride) and the elimination of any possibility for contamination of the product. Kellex—Kellogg subsidiary—designed the heat exchangers.

What about rocket engines? Operating temperatures up to 6000°F in the combustion chamber with the concurrent limitation of the radically lower temperatures that both containing metals and volatile coolants can withstand, *plus* minimum weight requirements, *plus* use of highly corrosive cooling substances . . . those "specs" truly add up to a major heat exchange problem. Kellogg continues to design and fabricate these newest power units.

You, of course, are familiar with refinery heat exchange requirements: high throughput and low maintenance. The requirements for marine condensers are also exacting in that breakdowns while in use cannot be tolerated. Kellogg fabricates these types by the shipload.

Next time you are ordering heat exchangers remember that Kellogg is one place in the country where you can get all this design and fabricating experience, in the field of heat exchange, *under one roof*. And remember too that Kellogg is continuing its exploratory work in atomic energy . . . expanding rapidly in the field of jet propulsion . . . continuing to improve its refinery exchangers . . . working on other types—all with the goal of lower costs, lower maintenance and higher efficiencies.

To master temperature, pressure and chemicals use

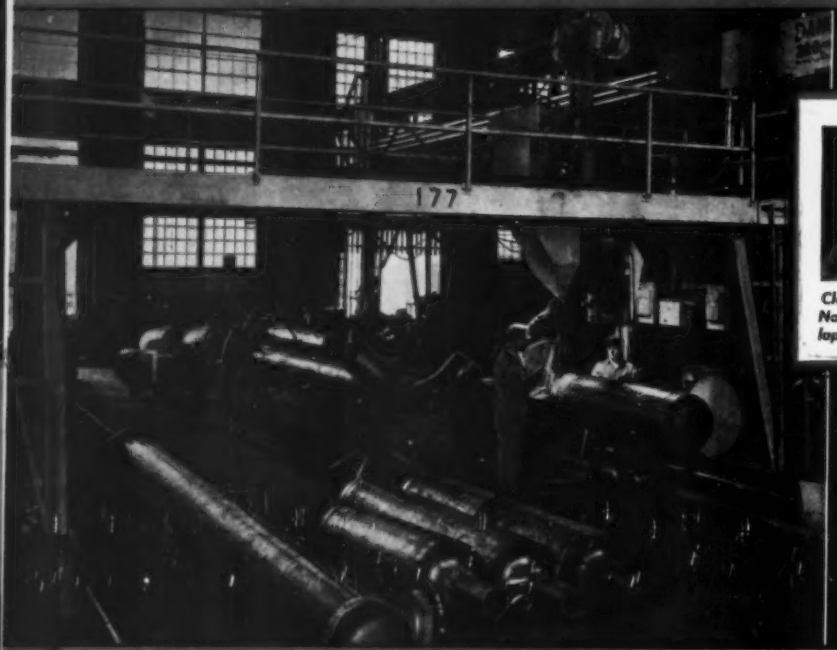
M. W. KELLOGG

process equipment

VESSELS • EXCHANGERS • CONDENSERS • HIGH PRESSURE AND HIGH TEMPERATURE POWER PIPING PROCESS PIPING • FORGED AND WELDED FITTINGS . . . IN ALL STEELS, ALLOYS OR SPECIAL COMBINATIONS

The M. W. Kellogg Company, Inc. (A Subsidiary of Pullman, Inc.) — Offices in New York, Jersey City, Buffalo, Los Angeles, Tulsa, Houston, Toronto, London and Paris.

PREFABRICATED PIPING IS IMPROVED



Closeup of the weld being laid. Note smoothness of the overlapping beads.

Movable bridge transports welding head and equipment over the various work rotating machines. Operator is shown adjusting flow of flux that submerges the arc; helper cleans weld with chipping hammer as it rotates past him.

by MIDWEST MACHINE WELDING

WITH SUBMERGED ARC

Operator stops machine at completion of weld by simply pressing button. Push button controls position welding head exactly over work clamped in rotating machine.

Better welding is assured by this Midwest development because the "human element" has been eliminated for all practical purposes. Aside from work positioning, the operator simply starts and stops the machine; his helper chips off the slag . . . all else is automatic.

Quality of the weld is improved because the machine follows the predetermined procedure *exactly . . . everytime.* The puddle is larger and the arc is better shielded and controlled. The possibility of locking up slag is minimized while undercutting is practically impossible. The greater number of beads is a further improvement.

This application equipment, developed and built by Midwest for use in its own fabricating plants, is representative of the modern facilities used by Midwest to assure better piping.

3477

MIDWEST PIPING & SUPPLY COMPANY, INC.

Main Office: 1450 South Second Street, St. Louis 4, Mo.

Plants: St. Louis, Passaic, Los Angeles and South Boston • Sales Offices: New York 7—30 Church St. • Chicago 3—79 West Monroe St. • Los Angeles 33—320 Anderson St. • Houston 2—229 Shell Bldg. • Tulsa 3—533 Mayo Bldg. • South Boston 27—426 First St.

PIPING FABRICATORS AND CONTRACTORS

MIDWEST PIPING SERVICE IS NATION-WIDE

4 PLANTS ARE BETTER THAN 1

In Refining OILS

FILTROL DOES *Both* JOBS BEST

LUBE OILS

In the contact filtration process, Filtrol's* highly activated, chemically prepared adsorbents provide greater diversification, higher quality, larger volume, at lower cost. This selectivity makes it possible for refiners to produce improved lubricating oils of outstanding bloom and brilliance—providing sales appeal that pays off.

TRANSFORMER OILS

TURBINE OILS

WAXES

WHITE OILS

SPECIALTY OILS

Because of the great flexibility of Filtrol adsorbents, refiners can produce a wide range of equally superior specialty oils. Lower labor costs, higher efficiency and minimum plant maintenance are the reasons that year after year more refiners are depending on Filtrol adsorbents.

FILTROL CORPORATION

General Offices: 634 S. Spring St., Los Angeles, California

Plants: Vernon, California and Jackson, Mississippi

CATALYSTS AND ADSORBENTS

RESEARCH AND DEVELOPMENT

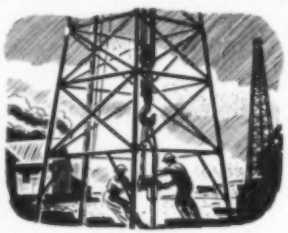
*Reg. U. S. Pat. Off.

Standard Oil Company (New Jersey) Reports for 1948...

A year of Progress and Results for an Oil-using World!..

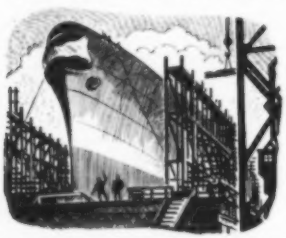
OIL SHORTAGE FEARS of a year ago have vanished. All around the world, oil resources are expanding. In doing their part to meet the rising needs for oil, this Company and its affiliates last year made the greatest efforts in their history. Here are some facts from this Company's Annual Report to its more than 200,000 stockholders . . .

1 TOTAL PRODUCTION AGAIN INCREASED. After setting new records in both 1946 and 1947, this Company and affiliates in 1948 increased crude oil production by 8% over the year before. Output of crude oil by our domestic affiliates represented 9% of the total crude produced in the U.S. Output of affiliates, world-wide, represented 14% of world production.



More wells drilled than ever before. Proved reserves increased

2 SEARCH FOR NEW OIL SOURCES SET RECORDS. More wells were drilled than ever before. Costs for this were a record $374,000,000 in 1948. Proved reserves in the earth at year's end were at a new high.



14 new Supertankers ordered, each nearly twice the size of wartime tankers

3 EVEN GREATER COSTS FOR EXPANSION AND REPLACEMENT were again required to meet rising needs for oil. Jersey Standard and affiliates spent a record $529,415,000 in 1948, even more than 1947's investment of 426 millions. For these needs and payment of dividends, money again was drawn from earnings, from borrowing, from sale of assets, and from further call on savings of past years.

4 NEW FACILITIES RESULTED ALL OVER THE OIL-PRODUCING WORLD. In Venezuela, the world's largest pipeline was completed. Fourteen new supertankers were ordered, each nearly twice the capacity of wartime tankers. At Montreal and Edmonton in Canada; at Billings, Montana; Linden, New Jersey; and Baton Rouge, Louisiana, new refining facilities for more and better oil products went into service. At Amuay, Venezuela, a new 60,000 barrels per day refinery neared completion.

New facilities like this modern refinery help increase oil supplies

5 RELATIONS WITH EMPLOYEES CONTINUED EXCELLENT. Again there were no domestic strikes or work stoppages. At year's end the gross investment in property, plant and equipment amounted to $26,600 for each of the 129,000 employees of Jersey and its affiliated companies.

6 BOTH INCOME AND EXPENDITURES ROSE. As reported in the consolidated statement, total income of all companies was $3,332,187,000, an increase of 40% over 1947. At the same time, costs were also up 40%. $1,386,248,000 was paid for crude oil and other supplies, $573,459,000 paid to employees, $492,000,000 for other operating costs. Taxes of $268,000,000 were paid.

7 RECORD NET EARNINGS, LARGELY PLOUGHED BACK. Consolidated net earnings totaled $365,605,000. Yet this total, plus affiliates' earnings assignable to stockholders other than Jersey, plus all of the year's depreciation allowances was just about equal to the amount of money put back into the business to meet pressing needs for expansion and replacements. Stockholders of Standard Oil Company (N.J.) received dividends of $2.00 per share of the Company's stock, plus a stock dividend of two shares for each 40 shares held.

For copies of the full report write Room 1626, 30 Rockefeller Plaza, New York 20, N. Y.

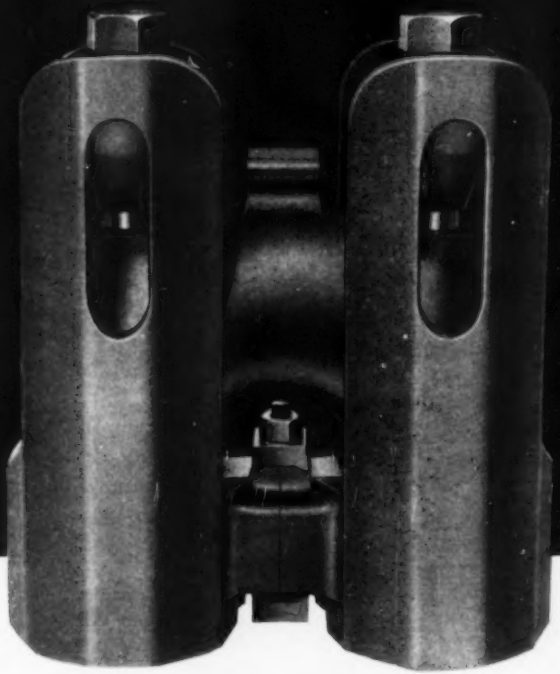
ALTHOUGH world oil consumption for the year increased 6.5%, and U.S. consumption 5.6% . . . the need was met and more. Threatened shortages were averted. Proved reserves in the earth are greater than ever before. New, modern facilities for meeting present and future needs are coming into operation throughout the world. Increasingly, human progress calls for more and more oil. In every way, the year 1948 was a year of progress and results for an oil-using world.

The better you live, the more oil you use!

STANDARD OIL COMPANY (NEW JERSEY)

AND AFFILIATED COMPANIES

OHIO Return Bends



TYPE 2000

Ohio Return Bends are designed to take advantage of the principle of directional solidification to give greater strength.

TYPE 2000 does not require rolling jigs for installation. Ease of single tube replacement saves valuable down time. TYPE 1000 is adaptable to wide general use under most operating conditions since materials in body and plugs are varied to suit individual needs.

Other types to suit many applications. Ohio Steel also produces special fittings if required. Write for details.

TYPE 1000

FAHRITE TUBE SUPPORTS

Where there's extreme heat for long periods of time, FAHRITE tube sheets, supports and hangers meet necessary strength requirements. They're field-proved. One of the many grades of FAHRITE will suit your operating conditions. Write for details.

The Ohio Steel Foundry Co.

SPRINGFIELD, OHIO Plants at Springfield and Lima, Ohio

DOWELL

SPECIALISTS IN SCALE AND SLUDGE REMOVAL WITH CHEMICALS

Cleaned! 757 cu. ft. of scale removed in 30 hours

Complex construction of Open Box Condenser is no problem for Dowell Chemical Scale Removal Service

An open box condenser at a Midwestern oil refinery was heavily coated with scale. *Within 30 hours*, Dowell Service removed an estimated *757 cu. ft.* of scale and the condenser was back in service!

Fast, effective cleaning of industrial heat exchange equipment is made possible by Dowell Service. Carefully selected solvents penetrate wherever water flows and are designed to remove troublesome scale from all surfaces contacted. Costly dismantling or modification is not required—the necessary solvents are pumped into the equipment using existing connections. When the scale is dissolved or disintegrated, the spent solution is pumped out, the unit flushed and put back in service. Expensive down time is held to a minimum.

Whenever you have a scale removing problem, look to Dowell. Experienced Dowell engineers do the job, bringing the equipment necessary to insure proper control at every stage of the operation.

Call the nearest Dowell office today for details about the fast, effective, and economical Chemical Scale Removal Service for boilers, heat exchange equipment, condensers, and water lines. Free estimates gladly given.

DOWELL INCORPORATED · TULSA 3, OKLAHOMA

SUBSIDIARY OF THE DOW CHEMICAL COMPANY

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New York 20, Boston 16, Philadelphia 2, Baltimore 18, Wilmington 99, Richmond 19, Atlanta, Buffalo 2, Cleveland 13, Pittsburgh 19, Detroit 2, Chicago 2, St. Louis 8, Indianapolis, Louisville, Kansas City 8, Wichita 2, Oklahoma City 2, Houston 2, New Orleans 12, Ft. Worth 2, Shreveport 22, Anniston, Alabama, Mt. Pleasant, Mich., Hamilton, Ohio, Charleston 27, W. Va., Salem, Illinois, Borger, Texas, Midland, Texas, Wichita Falls, Texas, Lafayette, La.

Long Beach, Oakland, Casper: Dowell Associate—International Comentors, Inc.

DOWELL

A SERVICE ORGANIZATION

PETROLEUM
REFINER

VOLUME 28, NO. 6 JUNE, 1949

The LOOK BOX

THE powerful corrective forces of a free market eliminated the postwar threat of a Pacific Coast oil shortage so fast that the advocates of some form of government control of petroleum hadn't even time to complete their plans.

Corrective Force Of a Free Market

This analysis of the changes which have recently occurred in the West Coast petroleum situation is by Marion E. Dice, economist of General Petroleum Corporation, Los Angeles.

The petroleum industry was faced with a 50 percent increase in population and an 81 percent increase in over-all demand for liquid petroleum products between 1939 and 1948.

"It is no wonder that in the face of these demands a few people underestimated the resourcefulness of the petroleum industry and raised their voices in fear of an oil shortage," Dice said.

"Fortunately the powerful corrective forces of a free market were already at work, and before the planners and controllers could get their blue prints ready for the new Congress, the supply situation changed from scarcity to surplus."

The solution "came faster than the planners could plan," commented Dice.

A "VERY GRADUAL" swing, covering perhaps several decades, from petroleum and natural gas to coal as the nation's principal source of fuel and the ultimate replacement of natural oil products by synthetic products has been forecast by T. R. Rhea of General Electric Company.

Petroleum and Electric Power

The manager of the Chemical and Petroleum Division of G. E.'s Industrial Engineering Divisions said he was making this forecast even though at the present time more Btu.'s are obtained from petroleum products than from coal.

"Such a trend," he declared, "cannot continue because the U. S. does not have unlimited petroleum reserves. A gradual swing back to coal based power means that more of this power will be transmitted as electric power."

Economics based on the steadily increasing value of petroleum as it becomes scarcer, he said, will force major American industries to turn to coal as the basis for electric power. "To conserve existing oil stocks," he said, "petroleum, natural gas and synthetic liquid fuels must be diverted from many industrial uses and conserved for use in automobiles, airplanes, diesel-electric locomotives and ships, and special industrial heating processes."

"With these factors in mind," Rhea declared, "there is every reason to expect that natural petroleum fuels will in the more distant future be replaced by synthetic fuels and petroleum products from oil shale. Also, undoubtedly there will be marked changes in the use of natural petroleum products."

He pointed out that there is sufficient oil shale and coal in the U. S. to provide the equivalent of two billion barrels of crude oil a year for at least 1000 years.

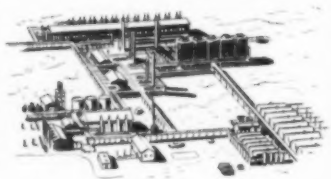
The manufacturing of synthetic fuels from coal or natural gas by the thermal-mechanical process will, he said, require staggering amounts of electrical, as well as mechanical, power. "A program of two billion barrels of liquid fuel from coal a year would require 700 billion horsepower hours per year to produce, a considerable portion of which would be electric power." This quantity of power, he said, is almost twice that now generated by electric utilities in a year's time.

Electric motors, Rhea said, now drive pumps on something less than half of the nation's 90,000 miles of crude and products pipe lines, but he added that almost 90 percent of all new lines are being electrified. Refineries, likewise, are being increasingly electrified, the consumption of electric energy having risen from 1 kwh. per barrel in 1920 to about 3.5 kwh. per barrel at the present time. As petroleum products become increasingly valuable, more energy per barrel will be expended on them to refine them more highly, he thought.

Rx PRESCRIPTIONS FILLED QUICKLY AND ACCURATELY

● A complete, permanent city set up by Brown & Root on Guam Island. Constructed to meet rigid governmental requirements, this community poses every problem of construction and development. When completed, it will stand as an achievement of overall planning and competent contracting covering every phase of the operation.

● Spanning more than three miles of Louisiana lowlands, construction of this "Brown-Bilt" trestle required specialized equipment designed to combat the unstability of swampy soil prevalent in Louisiana floodways. Reinforced concrete, set on 675,500 lineal feet of piling, assured an engineered travelway of staunch stability . . . a complete Brown & Root project fulfilling the maximum requirements of client specification.



● Shell Oil Company's TXL Gasoline Plant near Odessa, Texas. This is a prime example of Brown & Root's flexibility in meeting the demands of a client's changing conditions. The original contract called for a 30,000 *mcf* gasoline plant. During plant construction the *mcf* was revised to 45,000. Shortly after completion, the throughput demands were raised to 90,000 *mcf* . . . triple the original requirements! Farsighted planning by Brown & Root engineers allowed continuous plant operation while this tremendous project was effected.

● Offshore drilling. Derrick foundation constructed by Brown & Root Marine Operators, Inc., for a drilling operation far out in the Gulf of Mexico. "Brown-Bilt" in six fathoms of open water, its crown block towers 237 feet above the floor of the turbulent Gulf. It must withstand not only storms of hurricane strength but also the rigors of heavyweight rotary drilling operation.

BROWN-BILT

BROWN & ROOT, Inc. *Engineers - Constructors*

P. O. BOX 3, HOUSTON 1, TEXAS

CABLE ADDRESS — BROWNBILT

Associate Companies:— BROWN ENGINEERING CORP. ● BROWN & ROOT MARINE OPERATORS INC.

Rhea said electric power will play "an ever increasing role" in the petroleum industry as the natural petroleum products become more valuable. "Such electric power," he declared, "can be based on coal, thereby saving even more precious petroleum products."

"Beware the Ides of March"

W. ALTON JONES, president of Cities Service Company, as should be every thoughtful American, is concerned with the rising cost of government and, concurrently, the increasing tax rate. In a recent issue of *Service*, Mr. Jones states facts and views that should be of interest to every American who would see our country move forward and our standard of living improve.

"This nation, alone of all the nations of the world, has had from the beginning an expanding economy, a condition where everyone grows because he is active and prosperous," Mr. Jones points out. "It was blessed with low government expenses, which left money in pockets to take risks on *new* industries, which alone provide such expansion. In the 30-year period from 1900 to 1930, 100 billion of such savings developed industries which did not exist in 1900. Eighteen of these new industries, such as aviation, plastics, electric appliances, automobiles, radio, accounted for 40 percent of the total jobs in 1930!

"This was possible because in 1900 only 5 percent of the incomes of all of us went to state, local and federal governments as taxes. Today it is 35 percent which, after the nation's bare living expenses are met, leaves little or nothing to risk on new enterprises.

"If we wish to continue the upward curve of our famed standard of living, we must reduce taxes and thus assure the availability of capital for expansion. There are two things the citizen can do just now toward that end: 1) get behind any plan that looks to greater economy and efficiency of present governmental activities; and 2) put every new legislative proposal to this test: Is it something government should do? Is it in the twilight zone, where cost is excessive and bureaucratic operation inefficient? Is it a proper activity of government but which might be postponed until the foreign recovery drain upon us is over?

"If any of us is in doubt as to what government should do, here is a definition by a great statesman, Abraham Lincoln:

The legitimate object of government is to do for a community of people whatever they need to have done, but cannot do at all, or cannot so well do for themselves in their separate and individual capacities. In all that the people individually can do as well for themselves, the government ought not to interfere.

"The Ides of March saw the passing of Caesar and the greatness that was Rome; we should see to it that our Ides of March does not terminate our famed expanding economy and thus frustrate the American dream of getting on and up in the world."

"Now Is the Time for—," Etc.

OIL Progress Week activities were outlined recently at a meeting of the Oil Industry Information Committee and while these particular words are being written for the purpose of reviewing the plans, principally they are intended to urge local groups not to delay too long their own arrangements. The success of the endeavor, expanded from a "day" in 1948 to a full "week" this year, depends almost entirely upon the aggressiveness of oil industry leaders in each community. And a sure sign of this aggressiveness is an early start and careful, enthusiastic planning.

The event, as heretofore announced, will be localized through OIIC district committees and associations. Booklets, leaflets, radio broadcasts, speeches and similar material will reach community groups early in September. And even before that there will be a manual pointing out the many possibilities for community activity and participation.

The objectives for Oil Progress Week are to be:

1) To increase public confidence in the oil industry by developing a broader base of public knowledge of the progressiveness and good citizenship of the oil industry;
2) To strengthen the relationships between the oil industry and the communities of America;
3) To present facts to the public to enable it to refute invalid criticisms of the industry.

In addition to Oil Progress Week plans, OIIC at its recent meeting said there would be ready shortly a presentation for use in meetings of oil company employes, one that will tell employes of the public relations problems faced by their industry and how best to meet them. A similar presentation is being prepared for dealers who thus would be armed with facts about the industry in order that they may discuss them intelligently, with their customers particularly.

These are all worthwhile avenues of approach and if everyone connected with the oil industry will lend a hand, then 1949 progress in solving these public relations problems should be quite noteworthy.

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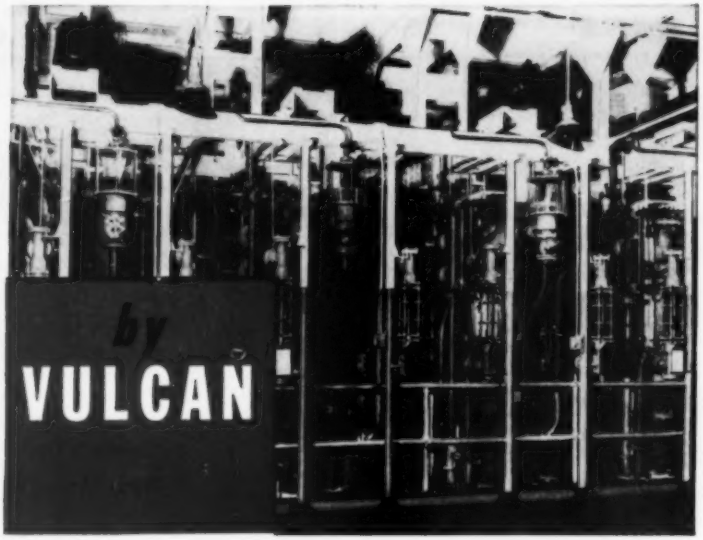

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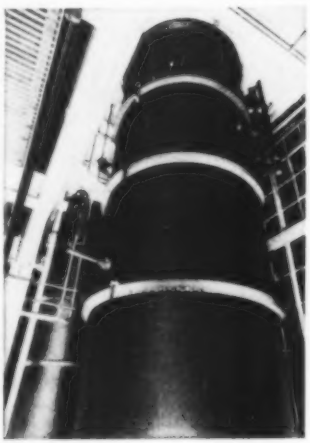

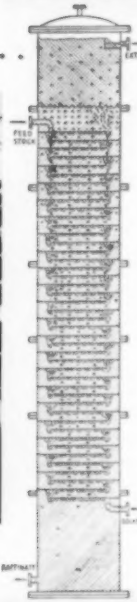

At right: Diagrammatic sketch of a liquid-liquid extraction column

THE Vulcan baffle-type liquid-liquid extractor consists of a vertical column packed with a series of horizontal baffles. The turbulent region at the edge of each baffle serves to remix the liquids between stages. Either phase may be the continuous phase. Each baffle is made horizontal and flat by the use of adjustable spacer posts.

This equipment has been highly successful in the organic chemical industry and it is equally suitable for hydrocarbon separations. Each new application is carefully checked in the Vulcan laboratories to assure economical design and to permit performance guarantees.

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The Outlook For Petroleum

JOHN W. BOATWRIGHT
General Manager
Distribution Economics
Department
Standard Oil Company (Indiana)

John W. Boatwright

THE future business outlook of all of us is subject to great uncertainty unless we all be vigilant in advocacy of, and defense of, the free enterprise system.

The economic outlook for petroleum products has changed drastically during the past year and today as we look at the supply, demand and stock situation, it is obvious that the industry has re-established conditions comparable with those prior to the war. Only today it operates at a level approximately 1,300,000 barrels daily higher.

Intense competition exists and will continue to exist in our industry. Competition for the buyer's dollar within the units of the oil industry, and among all industries, will characterize the year 1949. Now that a large part of accumulated demand has been satiated, we return to an economy where production will be geared largely to current use as reflected by normal wear and depreciation, and that necessary for an expanding population or an expanding standard of living of the population.

As to the demand, supply and stock conditions of our industry, the only safe answer about the future is to say that we shall have to watch and see what develops. If we may assume that political and social developments will not result in a marked deviation from those that have characterized the economy in the past two years, here is my evaluation of the outlook:

Dr. Boatwright, born in Kansas in 1903, has been with Standard Oil Company (Indiana) since 1932 and since 1937 has been head of sales research. All this time he has been engaged in the analysis of economic problems of the oil industry for the company and, during the war, for District II and national committees on economic problems. He gave the accompanying address before the annual meeting of the Consumers Co-operative Association late last month.

Dr. Boatwright for a number of years was industrial examiner for the Federal Trade Commission and for a period also served on the faculty at Northwestern. It was at this school where he received his doctorate in 1932. His M.A. (1929) was from the American University, Washington, D. C.

The demand for gasoline by the end of 1949 will probably reflect a consumption rate averaging between 5 and 6 percent over 1948, this increase originating predominately from passenger cars. Agriculture demand will remain near the 1948 level. Commercial consumption will be slightly below last year because of a slow but persistent decline in business activities throughout the remainder of the year.

The tractor consumption of petroleum should remain at or near the 1948 levels with gasoline continuing by far the most heavily demanded fuel for this use. Some strides have been made in diesel power for tractors, but in the Mid-west section of the country, gasoline-powered tractors constitute approximately 90 percent of the total tractors in use. With the return of gasoline to an abundant supply and intensive competition among the suppliers, it is likely that the consumption of tractor fuels other than gasoline and diesel fuel, will decline even further during the year.

Stocks of gasoline plus industry capacity to replace such stocks indicate an adequacy in sight throughout the nation.

Kerosine and No. 1

Stocks of kerosine and No. 1 burning oil and light diesel fuel during the past six months appeared definitely on the high side and were not depleted according to normal seasonal experience due to the mild winter east of the Mississippi River.

There probably will be a 9-to-10 percent increase in consumption of kerosine and No. 1 for 1949. This increase will be achieved notwithstanding a demand in the first four months that was about 12 percent below the corresponding period of 1948. The increase will result from additional installations of space heaters and provided we have normal weather in the fourth quarter. Full supply requirements throughout the year and in all sections of the country are anticipated.

Distillate Demand

The demand for distillates for the first four months of the year is off approximately 3 percent. This probably is due to reduced consumption and delayed buying incident to inventory depletions by consumers and secondary distributors.

The Bureau of Mines "demand" does not reflect actual rate of consumption for short time periods, but is in fact only the shipments from refineries and terminals. We all know there has been delayed buying. We hope that there has not been an over-correction of inventories on the part of some large consumers, which action will place in jeopardy their requirements for the future. Such a situation could develop. Delayed buying inevitably throws the entire problem of inventories against future needs on the oil industry. Whether adequate tankage exists to perform that function for the total economy is questionable.

When the buyers re-enter the market to insure future needs, as additional fuel oil burners are installed, and if the fourth quarter of the year represents normal weather conditions, it would be my expectation that requirements for distillates in 1949 would be approximately 10 percent higher than last year's consumption. Current stocks are high for this time of the year. Industry has the

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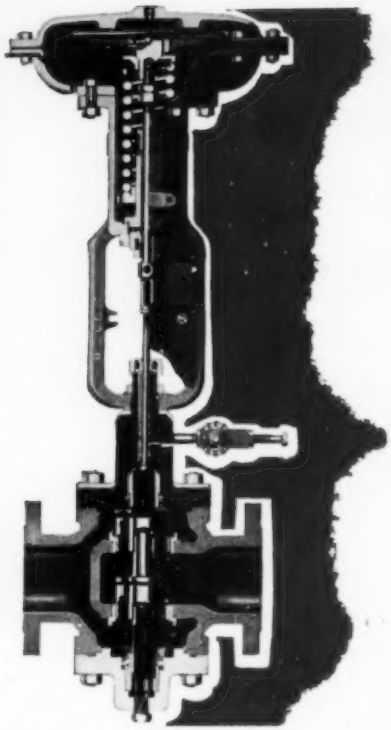

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capacity to produce substantial quantities above present levels. There are grounds for belief that the industry can meet all needs throughout the entire nation, but it will have to have some aid on storage during the next four months. If large users enter the winter with depleted inventories and throw their needs on the market on top of peak seasonal requirements for heating uses, there may be trouble.

Estimates of the market for residual fuel oils range from a loss of approximately 4 percent to a gain of perhaps 6 percent. During the first four months of 1949 our estimate is that residual fuel demand declined by approximately 5 percent.

Residual fuel is in the by-product classification—a relatively small amount of crude oil is processed primarily for the production of residual fuel. Factors affecting the total quantity of residual fuel produced include: a) the level of refinery operations; and b) the level of refinery yields as influenced by the selection of crudes processed and the manner of utilization of refinery facilities.

It is obvious that processing marginal high residual fuel bearing crudes will be replaced by light gravity crudes, if such are available. This will tend to reduce the over-all refinery production. Marginal, less efficient crude processing units will not be utilized to the extent they were in 1948, which again will tend to reduce the availability of residual fuel. On the other hand, the total crude runs in the nation probably will be higher than in 1948. That will tend to increase the total availability of residual fuels. Residual fuel utilized in this nation during 1949 should increase as much as 5 percent.

Lubricating Products

Many of the factors influencing the level of demand for lubricating products are in the direction of reducing demand. Motor oil ratios to gasoline sales have evidenced a long-term decline. Total consumption has been held to the levels that it has by increased gasoline consumption. Part of the decline of motor oil ratio is attributable to more efficient engines and part appears to be a reflection of the lengthened time intervals between motor oil changes. This latter tendency appears to be dangerous and unwise. The motorist is assuming an unwarranted degree of risk with a high cost mechanism when he gambles the safety of his motor against the relatively small insurance price incident to effective engine performance based on proper lubrication practice. In the industrial lubricating oils category, a decline in the level of requirements most probably will accompany the decline in industrial activity. Over-all, the demand for lubricating oils likely will show a decline in 1949 from 1948 levels by approximately 4 percent.

The oil industry in 1949 will be able to produce, transport, refine and deliver petroleum products where they are wanted, and in an adequate quantity to meet all requirements provided the consumers share in the storage responsibility as indicated above. This is a tremendous accomplishment for an industry that less than two years ago was faced with shortages in almost every product line.

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1948:									
January 31	5,318	5,434	228,083	15,986	102,973	7,690	40,580	9,141	50,839
February 28	5,387	5,463	226,860	15,796	111,040	7,963	33,836	8,824	49,206
March 27	5,377	5,324	229,409	15,783	112,991	7,682	30,717	8,854	48,334
April 24	5,415	5,517	228,488	16,515	111,128	6,831	34,237	8,877	49,572
May 29	5,452	5,715	228,979	17,827	107,185	7,054	38,641	9,508	55,146
June 26	5,494	5,674	229,632	17,938	104,178	7,200	45,166	8,858	58,812
July 31	5,455	5,718	230,720	17,646	99,116	6,823	56,661	9,080	65,713
August 28	5,529	5,682	229,873	17,722	95,504	7,491	66,321	8,818	70,853
September 25	*5,343	4,789	*234,193	15,100	78,669	5,997	81,884	6,390	37,326
October 30	5,604	5,626	239,702	17,569	91,925	7,679	81,593	8,853	81,299
November 27	5,617	5,721	244,246	17,317	39,802	7,476	85,151	9,477	86,192
December 25	5,641	5,784	250,555	18,178	100,286	7,776	79,271	9,121	86,181
1949:									
January 29	5,493	5,490	255,459	17,531	114,677	7,547	67,432	8,178	84,462
February 26	5,401	5,412	261,965	17,621	124,382	7,430	57,746	8,225	80,246
March 26	5,188	5,353	266,506	17,417	128,087	6,167	48,721	8,305	55,792
April 30	4,980	5,273	271,255	17,969	124,787	6,681	49,959	8,185	60,174
May 21	4,959	5,307	274,042	18,230	120,469	6,177	†54,282	8,354	†63,080

* Total U.S. All other September 25 figures do not include California, due to strike.
† Fuel oil stocks on new basis since March 26, 1949, and not comparable with previous totals.

Recall the assumption made at the beginning, that there be no significant deviation of political and social atmosphere for the oil industry during 1949. Estimates such as given should be taken in the light of three conditions, any one of which may render the entire aforementioned discussion of outlook absolutely worthless. These are deviations appearing on the horizon incident to political and economic environment:

1) Washington legislative bodies have before them five bills—three Gillette bills, the Langer bill, and the Patman bill. Each of which is designed for and looks toward a dismemberment of the oil industry. Dismemberment of the industry will set in motion untold and unpredictable series of changes detrimental to the industry and to the public. These measures set in motion social requirements directly contrary to the principles of free enterprise and to greatest efficiency. Permit these assertions:

A. The future of our country is best insured by intense competitive activity and the continual quest for ways and means to bring about lower cost of operations in supplying petroleum requirements. Dismemberment of the industry will lead to higher costs.

B. It is sound business practice to spread the risks incident to operations of an oil company both functionally and geographically so as to afford greater stability and continuity of service, eliminate costly shutdowns, and place each operator in position to offer an unqualified guarantee to his customers that their petroleum products can be adequately furnished. This is best accomplished by synchronizing the various economic steps between natural resources and the satisfaction of human wants. Call this integration if you will.

Advantages of Integration

C. This industry must take full opportunity of the advantages centering about research patents, and utilization of all possible by-products from the normal handling of petroleum products. Research is a cohesive factor running entirely through an organization. Integration is an important attribute to sound petroleum research now and in the future.

D. Association of the various segments of the petroleum industry under common management places the particular supplying company in a better position for determining and maintaining the quality of products sold and for procuring and maintaining brand identification associated with quality products through sales promotion and advertising. Integration is an essential ingredient for the achievement of this objective.

Capital Requirements

E. The rapidly expanding market for petroleum products has required and will continue to require tremendous capital resources. Capital resources will not be attracted in adequate quantities if the various units of the industry are atomized.

F. Superior executive control and better coordinated planning for the utilization of the capacities of each of the various segments of an oil company are possible when stemming from a common managerial source. As the units within an industry are better managed, the industry in total is better managed.

G. Adequacy of military supplies will be magnified and our national security placed in jeopardy if the oil industry is dismembered. The problem of military logistics will then go all the way back to discovery of crude oil.

H. Progress of the industry will be definitely checked for a period of many years.

It is difficult to believe that these measures are seriously offered as being in public interest. If they become the law, any estimate made in the absence of such rules would not be expected to be applicable.

2) Confusion concerning the legality of pricing practices characterizes our political thinking as evidenced by the Federal Trade Commission, the courts, and the Congress. In the Cement case, the Supreme Court in its side remarks raised questions concerning the legality of the entire field of basing point prices and freight absorption even where necessary to meet competition. This case was followed by the Rigid Conduit case in which the Seventh Circuit Court appar-

ently decided that individual and independent simultaneous use by several supplying companies of a basing point delivered pricing system is also unlawful, even when conspiracy was not charged. This case was carried to the Supreme Court which recently divided four to four concerning the issues involved. Hence, even the Supreme Court of the land could not decide clearly the principles of the law that were applicable to legal and illegal pricing systems.

Effect of Court Ruling

If prohibition of freight absorption becomes the binding law of the land, will not a major segment of the petroleum industry have to seek new plant locations or adopt prices so low at its refinery source of supply that it can still ship into freight disadvantageous territories? An f.o.b. mill price on all shipments low enough to reach freight disadvantage territories in many cases may be ruinous. There may be a general exodus from the petroleum industry in large areas remote from consumption centers. Some sections of the country will not have an adequate supply. Either that or the jobber will have to pay the full freight from the actual shipping point himself or attempt to find another supplier advantageously located freightwise so that his costs may equal the costs of a competitor.

The major consideration here is that the buyer is denied the free choice of his source of supply under the current thinking of the FTC. When a buyer is denied a free choice of supply, then inevitably a supplier in a particular area has a monopoly or has greater monopolistic power in a given market than he had before. If this thought be accepted, industry stagnation will be the inevitable consequence.

Naturally, petroleum products are tremendously affected by general business conditions, and if these deductions be correct, price confusion or a complete clarification of the confusing issues by adoption of the concepts of the FTC will be adequate to modify greatly any estimate of the 1949 demand.

3) A third major uncertainly involves a test case against Standard Oil Company (Indiana) which markets a preponderance of its output through its own facilities but does, however, have a few jobbers. FTC brought suit under the Robinson-Patman act asking Standard to justify the differences in its price received after granting a functional discount to the jobber and the price received when marketing directly through service stations, on a basis of the differences in costs of serving the two types of accounts. Standard's first plea that the transactions involved were not in interstate commerce, was denied.

Prohibition to Competition

Secondly, the company claimed that the functional discounts granted were necessary to meet competition. There is no argument on this point. Notwithstanding this admission, it was held that even though our action was necessary to meet competition, we had, in that manner, adopted steps that were counter to the law. The FTC was upheld in this opinion by the Chicago Appellate Court and the easy out suggested to the company was that it could give up such jobbing accounts. It is true, we can. It is equally true that if we do, and if all other suppliers must elect to distribute either direct or through jobbers—one or the other, but not both in the same area—then you may depend upon another major series of economic consequences being set in motion. And if that applies to the oil industry, will it also not apply to the other industries? Again, the buyer has been denied the right to select his source of supply.

It is most difficult to impress upon some people's minds that this mixed form of distribution results in competition of the highest order. It is physically impossible to protect each and every one of these various channels of distribution against being hurt and still preserve competition. And competition in a free enterprise economy is the basic principle upon which our social and economic growth has been predicated.

Our third point of defense was predicated upon cost justification. There is no need to elaborate the point of getting accountants to agree on cost classifications. We found, as any of you will find undoubtedly in the future, that this led only to confusion and conflicting opinions.

If the entire segment of middlemen distributors are thrown into jeopardy no one can foresee all of the economic consequences. But be it a stock company or a cooperative distributor in a particular community, he is going to face same new and major problems both concerning his future supply and his freedom to do business in the way in which he is accustomed and under the system within which he has built his organization.

These uncertainties are of vital interest to all of us. So business men are urged to look into them and determine the effects they will have on their future operations. If those effects as evaluated, upon careful study and consideration, are detrimental, you should so state to your elected representative. If those effects, predicted upon equally careful study and evaluation, are termed advantageous to you in your activities as a cooperative buying association, then in like manner you should so state. It is to be hoped that we may continue to live in a democracy in which the rules of conduct will be designed by its people and that democratic principles will be the means whereby we solve our problems.

Refinery Hourly Workers Rate High in Wage Levels

Average hourly earnings of petroleum refinery workers are third highest in American industry, a special survey by the Bureau of Labor Statistics revealed last month. Earnings of coal miners and the mechanical employes of newspapers and magazines are the only ones that exceeded those of refinery workers as of September, 1948.

The study included 122 refineries with more than 100,000 employes, the bureau explained. Complete findings will be made available shortly.

Earnings were, on the average, highest in the Great Lakes region and lowest in the Middle West. Refineries located in large cities paid higher rates for comparable jobs than those in small communities and plants with 500 workers or over had a higher wage level than smaller units.

Straight-time average hourly earnings for the refinery group were $1.78 an hour and about three-fourths of the employes studied earned between $1.50 and $2.10 an hour. Laborers averaged $1.42 hourly with occupational averages ranging up to $2.18 for stillmen operating continuous units. Two dollars per hour was the average for skilled maintenance workers.

Nearly all companies had some type of insurance and pension plans and in addition had liberal vacation, sick leave and paid holiday practices. More than 70 of the 122 plants had provisions in effect for payment of old age pensions.

European Plant Expansion Details Are Expected Soon

Assessment of individual Marshall Plan countries and companies are being made and it is expected that Economic Cooperation Administration shortly will be in position to commence financing of some European refinery projects. A 66-million-ton program was originally proposed by the countries, this capacity figure being an increase of some 50 percent over the ECA proposed 42 million ton level.

Review of the requests is being made by O. P. Cottrell, formerly of The Texas Company and Will Dodge who are studying project applications.

ECA advised Marshall Plan countries some time ago it is willing to underwrite projects on an initial basis calling for total European refining capacity of 42 million tons annually by 1952. This would include projects scheduled for private financing by American companies or to be built with free dollars by European companies.

Refiner's Margin Drops Sharply in Six Months

The refiner's margin or spread dropped 35 cents per barrel or some 30 percent between October, 1948 and April, 1949, according to figures announced last month by the Independent Petroleum Association of America which pointed especially to the squeeze of small, non-integrated companies. It was a matter of having been caught between declining prices for products and a fairly steady market for crude.

Weighted average prices for gasoline, kerosine, light fuel and heavy fuel were compiled for the nation's nine principal refinery markets and compared with crude prices for eight of the principal producing areas. It was felt that the weighted price of these four chief refinery products would reflect accurately the whole situation.

In October, 1948 the refiner's margin was $1.15 per barrel, crude averaging $2.59 and the product average $3.74. This spread had dwindled to 80 cents in April, the two averages being $2.56 and $3.36. This was the lowest since 1943 when it began a gradual climb from 78 cents per barrel.

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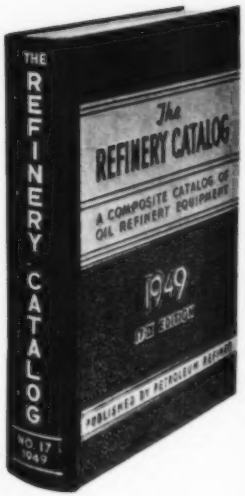

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REFINERY and Other PLANT CONSTRUCTION

Petroleum Refiner's exclusive feature which, in boxscore form, presents a quick picture of the tremendous amount of plant construction work that is in progress or projected by oil and other companies in all sections of the world.

The tabulation presented each month under the heading "Refinery and Other Plant Construction" represents a continuing check of the building program that is in progress in the refining, natural gasoline and petrochemical industry. Since August, 1947, it has appeared as an exclusive feature in PETROLEUM REFINER and it has proved a valuable aid and guide to our readers.

Companies whose projects are not listed or readers who know of projects not listed are urged to: 1) send in data on such units as called for by column headings; 2) furnish details which are missing in any item in the current tabulation, and 3) report from time to time on the progress of these projects. Address, Editor, PETROLEUM REFINER, Box 2608, Houston 1, Texas. Cooperation together with suggestions are very much appreciated.

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
EAST									
*E. I. DuPont	Parkersburg, W. Va.	Tetrafluoroethylene Resin Plant			Under Constr.	Summer, 1950			
Esso Standard Oil	Linden, N.J.	Vac. pipe still	40,000 bbls.		Under Constr.	2nd Qtr., 1949		S.O.D. & Braun	Braun
Esso Standard Oil	Linden, N.J.	Cat. Crack, Light Ends	41,000 bbls.		Under Constr.	3rd Qtr., 1949		S.O.D., Braun	Braun
Esso Standard Oil	Bayonne, N.J.	Dewaxing	7,500 bbls.		Under Constr.	1st Qtr., 1950	Texaco	Badger	Badger
Esso Standard Oil Co.	Linden, N.J.	Steam Boiler	260,000 lbs. hr.		Under Constr.	2nd Qtr., 1949		S. O. D.	
Esso Standard Oil Co.	Bayonne, N.J.	Steam Boilers	400,000 lbs. hr.		Under Constr.	2nd Qtr., 1950		S. O. D., Day & Zimmermann	S. O. D., Day & Zimmermann
Freeport Sulphur Co.	Westville, N.J.	Sulfur Recovery Plant	40 tons		Contracted				Girdler
Gulf Oil Corp.	Philadelphia, Pa.	Topping and Vacuum Unit	30,000 bbls.		Under Constr.	Nov., 1949		Lummus, Badger	Lummus
Socony - Vacuum Oil Co., Inc.	Paulsboro, N.J.	Crude, Dist. Unit	19,500 bbls.		Under Constr.	Mid 1949		Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Propane Deasphalting	5,950 bbls.		Under Constr.	Mid 1949	Juik	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Furfural Refg.	4,450 bbls.		Under Constr.	Mid 1949	Texaco	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	MEK Dewaxing	2,050 bbls.		Under Constr.	Mid 1949	Texaco	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Clay Contact Unit	3,000 bbls.		Designing	Late 1949		Badger	Badger
Socony-Vacuum Oil Co., Inc.	Paulsboro, N.J.	Light Oil Treating Plant	28,000 bbls.		Designing	Mid 1949		Badger	Badger
L. Sonneborn Sons, Inc.	Petrolia, Pa.	Enlarge Anti-Pollution		$400,000	Under Constr.	Middle 1949		Chemical Constr. Co.	Morris Knowles & Co.
Sun Oil Co.	Marcus Hook, Pa.	Wax			Under Constr.	July, 1949	Texaco	Staff	Staff
Sun Oil Co.	Marcus Hook	Comp. & Pkg.			Under Constr.	August, 1949		Staff, Lindsay	W. W. Lindsay
The Texas Co.	Beacon, N.Y.	Expand Research Labs.			Under Constr.	Jan., 1950		Voorhees, Walker, Foley & Smith	
The Texas Co.	Westville, N.J.	New Refinery	40,000 bbls.		Under Constr.	July, 1949		Foster-Wheeler, Jackson-Moreland, Kellogg	Foster-Wheeler, Kellogg
Tide Water Associated Oil Co.	Bayonne, N.J.	Furfural Refining Unit				Completed	Texaco	Pritchard	Pritchard
U.S. Dept. of Interior	Bruceton, Pa.	Fischer-Tropsch Pilot Plant (Coal-to-gasoline synthesis)	1-2 bbls.	$150,000	Under Constr.	Nov., 1949		Staff	Blaw-Knox Co.
MID-CONTINENT									
Ashland Oil & Refining Co.	Canton, Ohio	Ref. Modernization			Under Constr.	Middle 1949			Cat. Constr.
The Carter Oil Co.	McKamie, Ark.	Pressure Maintenance Unit	38,000 mcf		Under Constr.	July, 1949		J. & L. Constr.	J. & L. Cons
Champlin Refining Co.	Enid, Oklahoma	Crude Unit	18,000 bbls.	$600,000	Under Constr.	Fall, 1949		Koch	Staff
Champlin Refining Co.	Enid, Oklahoma	Cat Poly Unit	450 bbls.	$200,000	Under Constr.	Fall, 1949	U.O.P.	Koch	Staff
Cities Service Oil Co.	Chicago, Ill	Compounding & Grease Plant	1,200 bbls.	$4 million	Under Constr.	Late 1949		Sumner-Sollitt	Sumner-Sollitt
Cooperative Refinery Association	Coffeyville, Kansas	Dewaxing	2,200 bbls.	$1.5 million	Contracted	3rd Quarter, 1949	Texaco	Process Eng.	Process Eng.
Cooperative Refinery Assoc.	Coffeyville, Kansas	Modernize Gasoline Plant	20,000 bbls.	$900,000		Completed	U.O.P.	U.O.P., Staff	Staff
Continental Oil Co.	Ponca City Oklahoma	Crude Dist. Unit	30,000 bbls.		Under Constr.	Oct., 1949		Bechtel	Bechtel
Dewese Oil Co.	Weston, Ohio	Lube Filtering Unit	250 bbls.	$15,000	Under Constr.	Summer, 1949		Staff	Staff
The Globe Oil & Refining Co.	Lemont, Ill.	Cat. Cracker Unit	6,000 bbls.	$1 million	Buying Material	Jan. 1, 1950	U.O.P.	U.O.P.	
Gulf Oil Corp.	Kiefer, Okla.	Expand Gasoline Plant	14,500 mcf		Under Constr.				
Gulf Refg. Co.	Toledo, Ohio	Fluid Cat. Crk.	15,500 bbls.		Under Constr.	Sept., 1949		Kellogg	Kellogg
Gulf Refg. Co.	Toledo, Ohio	Poly Unit	5,000 bbls.		Under Constr.	Aug., 1949	U.O.P.	Kellogg	Kellogg
Gulf Refg. Co.	Cincinnati, Ohio	Fluid Cat Cracker Unit	15,500 bbls.		Under Constr.	Oct., 1949		Kellogg	Kellogg
Gulf Refg. Co.	Cincinnati, Ohio	Poly Unit	5,000 bbls.		Under Constr.	Sept., 1949	U.O.P.	Kellogg	Kellogg

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15 years without a shutdown because of lubrication! That amazing record of modern steam turbine operation is just one example of how PARAMINS-improved lubricants are constantly setting new performance records for modern industrial machinery.

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REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Lion Oil Co.	El Dorado, Ark.	Enlarge Ammonia Unit	570 tons	$3.5 million		Completed		Chem. Constr.	Chem. Constr.
Lion Oil Co.	El Dorado, Ark.	Sulfuric Acid Plant	300 tons	$1¼ million	Under Constr.	Sept., 1949		Chem. Constr.	Chem. Constr.
Lion Oil Co.	El Dorado, Ark.	Ammonium Sulfate Plant	380 tons	$750,000	Under Constr.	Sept., 1949		Chem. Constr.	Chem. Constr., Blaw-Knox
M. F. A. Oil Co.	Chanute, Kans.	Desulfurization	1,000 bbls.	$75,000	Under Constr.	Sept., 1949	Phillips	Koch	Staff
Magnolia Pet. Co.	Grant County, Kans.,(Hickok)	Gasoline Plant	100,000 mcf		Under Constr.	Nov., 1949		Staff, Waleo	Waleo
Magnolia Pet. Co.	Grady County, Oklahoma	Pressure Maintenance & Cycling	35,750 mcf		Under Constr.	Dec., 1949		Staff, Constr.	Service Co.
Magnolia Petroleum Co.	Stephens County, Okla.	Gasoline Plant	30,000 mcf		Under Constr.	March, 1949		Staff J. & L. Constr.	J. & L. Constr.
Midland Cooperative Wholesale	Cushing, Okla.	Cat. Poly Unit	200 bbls.		Authorized	Early 1950			Ref. Eng., U.O.P.
Ohio Oil Co.	Robinson, Ill.	Vac. Unit Cat. Crack, Crude Still, Poly, LP G Recovery	27,500 bbls.	$15 million	Under Constr.	Mid 1950	U.O.P.	McKee	McKee, Pritchard
Petco Corp.	Blue Island, Ill.	Houdriflow Cat. Cracker Unit, LPG Recovery System	5,000 bbls.	$400,000	Under Constr.	Last Quarter, 1949	Houdry	Houdry	Clarke
*Petroleum Specialties, Inc.	Flatrock, Mich.	Additional Tankage		$85,000	Under Constr.	July, 1949			
Phillips Pet. Co.	Kansas Cy, Kans.	Cat. Crack	24,000 bbls.		Under Constr.	Oct., 1949		Braun	Braun
Phillips Pet. Co.	Kansas Cy, Kans.	Cat. Poly	1,500 bbls.		Under Constr.	Oct., 1949		Braun	Braun
Phillips Pet. Co.	Guymon, Okla.	Absorption Plant	173,000 mcf		Under Constr.	July, 1949			
The Pure Oil Co.	Toledo, Ohio	Revamping Crude Reforming Units			Under Constr.	1st Qtr., 1949			Cat. Constr
R. J. Oil & Refining Co., Inc.	Princeton, Ind.	Electric Desalter	1800 bbls.	$15,000		Completed	Petro	State Eng.	State Eng.
Rock Island Refg. Corp.	Rock Island, Ind.	Fluid Cat. Crk.	10,000 bbls.	$1,200,000	Under Constr.	July, 1949	U.O.P.	U.O.P.	Staff
The Shallow Water Refining Co.	Shallow Water, Kansas	Reforming Unit	1,250 bbls.	$85,000	Under Constr.	Fall, 1949	Perco	Koch Eng.	Koch Eng.
Skelly Oil Co.	Eldorado, Kans.	Crude Dist. Unit, Cat. Crk.	35,000 bbls.	$8-10 million	Under Constr.	Mid 1950			
Socony-Vacuum	E. St. Louis, Ill.	Crude Distillation	15,000 bbls.		Under Constr.	Aug., 1949		Bechtel, Staff	Bechtel
Socony-Vacuum Oil Co.	East St. Louis, Illinois	Thermal Cracking, Reforming, Visbreaker Unit	13,200 bbls.		Under Constr.	Dec., 1949		Staff, Bechtel	Bechtel
Socony-Vacuum Oil Co.	East St. Louis, Illinois	Tannin Solutiser Treating Unit	18,000 bbls.		Under Constr.	July, 1949		Staff, Bechtel	Bechtel
Socony-Vacuum Oil Co.	East St. Louis, Illinois	Miscl. Refinery Additions			Under Constr.	Sept., 1949		Staff, Bechtel	Bechtel
Socony-Vacuum Oil Co.	East St. Louis, Illinois	Delayed Coking Unit	6,000 bbls.		Under Constr.	Oct., 1949		Staff, Bechtel	Bechtel
Standard Oil Co., (Ohio)	Lima, Ohio	Furfural Refining Plant	76,000 gals.	$13 million	Contracted	1951	Texaco	Lummus	Lummus
Standard Oil Co., (Ohio)	Lima, Ohio	Cat. Cracking	16,000 bbls.	$11 million	Under Constr.	Late 1949	U.O.P.	McKee	McKee
Standard Oil Co., (Ohio)	Lima, Ohio	Crude Distl., Coke	†15,000 bbls.	$5 million	Authorized	Mid 1950	Kellogg	Kellogg	Kellogg
Standard Oil Co., (Ohio)	Lima, Ohio	Solvent Dewaxing Unit	1,800 bbls. Finished Products		Authorized	Mid 1950	Texaco	Lummus	Lummus
Standard Oil Co., (Ohio)	Lima, Ohio	Vacuum Unit	9,000 bbls.		Authorized	Mid 1950			Lummus
Standard Oil Co., (Ohio)	Lima, Ohio	Propane Deasphalting Unit	800 bbls.		Authorized	Mid 1950			Lummus
Sun Oil Co.	Toledo, Ohio	Cat. Crack, Crude Dist., Vac., Poly	30,000 bbls.	$16 million	Under Constr.	Jan., 1950	Houdry	Houdry, Cat. Constr., Process Eng., Staff	Cat. Constr.
Sun Oil Co.	Toledo, Ohio	Anti-Pollution	600,000			Completed		Staff	Cat. Constr.
The Texas Co.	W. Tulsa, Okla.	Expand, Modernize Refinery	30,000 bbls.		Under Constr.	July 1, 1949		Kellogg, Foster-Wheeler, U.O.P.	Kellogg, Foster Wheeler
The Texas Co.	Lawrenceville, Illinois	Expand Refinery	†20,000 bbls.		Design	Jan. 1, 1952		Foster-Wheeler, Kellogg	Foster-Wheeler, Kellogg
Tide Water Associated Oil Co.	Drumwright, Oklahoma	Houdriflow Unit Cat. Cracker	4,800 bbls.		Contracted		Houdry		Process Eng.
U.S. Dept. of Interior	Louisiana, Mo.	Demonstration Oil-from-Coal Plant	80 bbls.	$5 million	Under Constr.	Dec., 1949		Koppers	Koppers
West Cement Medrano Unit	Caddo County, Oklahoma	Gas Injection Facility	9000 mcf	$1 million	Under Constr.	July, 1949		Dresser	Dresser
Wood River Oil & Refining Co., Inc.	Hartford, Ill.	Vacuum Unit	15,000 bbls.	$700,000	Under Constr.	August, 1949		Koch	Staff
Wood River Oil & Refining Co., Inc.	Hartford, Ill.	Fluid Cat. Cracker	7500 bbls.	$2.5 million	Under Constr.	Dec., 1949	U.O.P.	Koch	Staff
SOUTHWEST									
The Atlantic Refining Co.	Block 31, Crane County, Texas	Gas Injection Plant	8,320 mcf			Completed		Hudson, Staff	Hudson
The California Co.	Brookhaven, Mississippa	Cycling Plant	10,000 mcf		Designing	3rd Qtr., 1949		Hudson	Hudson
Barnsdall Oil Co.	Placedo, Tex.	Compressor Station	2000 hp.	$380,000	Under Constr.	July, 1949		Olsen	Olsen
Calumet Ref. Co.	Princeton, La.	Blending Oil Tank House	700 bbls.		Under Constr.	3rd Qtr., 1949		Staff	Staff
Carthage Hydrocol, Inc.	Brownsville, Texas	Hydrocol	87,000 mcf	$26 million	Under Constr.	Dec., 1949	Hydro-Res., Inc. Texaco	McKee, Hydro-Res., Inc.	McKee
The Chicago Corp.	Carthage, Texas	Enlarge Gas Plt	210,000 mcf	$2 million		Completed		Fish Eng.	Fish Eng.
Cit-Con Corp.	Lake Charles, La.	Lube Plant	6,000 bbls.	$42 million		Completed	Texaco, Max B. Miller	Max B. Miller, Lummus	Lummus, Max B. Miller
Cities Service Oil Co.	Pampa, Texas	Gasoline Plant	18,000 mcf		Contracted	1949		Waleo	Waleo
Cities Service Oil Co.	Chico Field, Wise Co., Tex.	Natural Gasoline Plant	22,000 mcf		Planned	Early, 1950			Fluor
*Cities Service Oil Company	St. Rose, La.	Lube Oil Blending	1500 bbls.	$750,000	Under Constr.	Late 1949		Day & Zimmerman	Day & Zimmerman
Claiborne Gasoline Co.	Lisbon, La.	Enlarge Pipeline Absorption Plant	125,000 mcf		Under Constr.	August, 1949		Pet. Eng.	
Continental Oil Co.	Todd (Deep) Field, Texas	Gas Recovery Plant	10,000 mcf		Under Constr.	Sept., 1949		Ref. Maint.	Ref. Maint.
Coseden Pet. Corp.	Big Spring, Tex.	Fluid Cat. Plant	6,000 bbls.	$2 million	Under Constr.	Nov., 1949	U.O.P.	U.O.P.	Ref. Eng
Department of the Army	Houston, Tex.	Anhydrous Ammonia Facility	2100 tons monthly	$2.5 million	Relocating	Sept., 1949		Girdler Corp.	Hercules Powder Co.
E. I. duPont de Nemours Co., Inc.	Victoria Tex.	Chemical Intermediates for Nylon			Design	Early 1951		Staff	Staff

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REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Esso Standard Oil Co.	Baton Rouge, La.	Light Ends Recovery	20,000 mcf	.....	.....	Completed	.....	S.O.D., McKee	McKee
Esso Standard Oil Co.	Baton Rouge, La.	Light Ends	11,000 bbls.	.....	.....	Completed	.....	Braun	Braun
Ethyl Corp.	Baton Rouge, La.	Mfg. Facilities	.....	$40 million	Under Constr.	Oct., 1949	.....	Stone & Webster	Stone & Webster
*Esso Standard Oil Co.	Baton Rouge, La.	Mechanical Shops	.....	.....	Under Constr.	July, 1949	.....	Braun	Braun
Gulf Oil Corp.	Crane, Texas	Gasoline Plant	40,000 mcf	.....	Under Constr.	July, 1949	.....	Braun	Braun, W. H. Bowden
Humble O&R Co.	Katy, Texas	Add Propane, Absorption, refrigeration	Unchanged	.....	Under Constr.	Oct., 1949	.....	Stearns-Roger	Stearns-Roger
Humble O&R Co.	Kelsey Field, Texas	Gas Injection Plant	18,000 mcf	.....	.....	Completed	.....	Stearns-Roger	Stearns-Roger
Humble O&R Co.	Conroe, Texas	Add Absorption	30,000 mcf	.....	Under Constr.	August, 1949	.....	Stearns-Roger	Stearns-Roger
Humble O&R Co.	Heyser Field Texas	Gas Comp. Plant	22,000 mcf	.....	.....	Completed	.....	Bellco Ind. Piping Co.	Bellco Ind. Piping Co.
Humble O&R Co.	Opelousas, La.	Absorption Plant	110,000 mcf	.....	Under Constr.	August, 1949	.....	Hudson	Hudson
Humble O&R Co.	Pickton Field, Texas	Absorption Plant	18,000 mcf	.....	Under Constr.	July, 1949	.....	Fluor	Fluor
Humble O&R Co.	Baytown, Texas	Pipe Stills	45,000 bbls.	.....	Under Constr.	July, 1949	.....	Foster-Wheeler	Foster-Wheeler
Humble O&R Co.	Baytown, Texas	Lube Extraction	7,000 bbls.	.....	Under Constr.	Late 1949	.....	Kellogg	Kellogg
Humble O&R Co.	Flour Bluff Field, Texas	Compression Plant	12,500 mcf	.....	.....	Completed	.....	Tellepsen	Tellepsen
Humble O&R Co.	Imogene-Jourdanton-Charlotte Fields, Texas	Compression Absorption Plt.	28,000 mcf	.....	Under Constr.	1950	.....	.....	Hudson
Humble O&R Co.	Thompsons, N. Thompsons, S. Thompsons Field, Texas	Gas Compression Plant	18,500 mcf	.....	.....	Completed	.....	Brown Eng.	Brown Eng.
*Humble Oil & Refining Company	Tomball Field, Texas	Additional Compression Facilities	10,000 mcf	.....	Under Constr.	July, 1949	.....	Fluor	Fluor
Hutex Oil & Refining Co.	Hardin, Tex.	Fractionators for Solvents	1,000 bbls.	$50,000	Under Constr.	July, 1949	.....	Staff	Staff
Jefferson Chem. Co.	Austin, Texas	Central Research Facilities	.....	.....	Under Constr.	Sept., 1949	.....	Staff	Staff
*Jefferson Chem. Co. Inc.	Port Neches, Tex.	Increase Capacity	.....	.....	Engineer	1950	.....	Staff	.....
Lone Star Gas	Dallas, Texas	Hypersorption Plant	60 mcf	.....	Design & Eng.	1949	Union Oil Co.	Foster-Wheeler	Foster-Wheeler
Magnolia Pet. Co.	Seeligson Field, Texas	Gasoline and Cycling	†70,000 mcf Casinghead ‡150,000 mcf Cycled	.....	Under Constr.	Sept., 1949	.....	Hudson	Hudson
Midland Gasoline Co.	Conroe Field, Texas	Enlarge Gasoline Plant	100,000 gals.	.....	Under Constr.	Dec., 1949	.....	Gaso. Plant	Gaso. Plant
Monsanto Chemical Co.	Columbia, Tenn.	Smoke Washing Unit	.....	$750,000	.....	Completed	.....	Staff	Rust Eng.
Pan American Refining Corp.	Texas City, Texas	Expand Chemical Research Facilities	.....	.....	Postponed	Postponed	.....	Staff, H. K. Ferguson	Staff, H. K. Ferguson
Pan American Refining Corp.	Texas City, Tex.	Revamping Crude Unit	.....	.....	Engineering	Late 1949	.....	Tellepsen	Tellepsen
Panhandle Producing & Refg. Co.	Wichita Falls, Texas	Cat. Cracker	1,500 bbls.	$1 million	Engineering	March, 1950	U.O.P.	U.O.P., J. & L. Constr.	J. & L. Constr.
Petrol Refining, Inc.	Texas City, Texas	Crude Topping Units	50,000 bbls.	.....	.....	Completed	.....	Rust. Eng.	Rust. Eng.
Phillips Chemical Co.	Etter, Tex.	Anhydrous Ammonia	†70,000 tons year	$5.3 million	Under Constr.	July, 1949	Chem Constr.	Chem. Constr.	Brown & Root
Plymouth Oil Co.	Rankin, Texas	Gas Compression, Absorp.	70,000 mcf	$5½ million	Under Constr.	1949-50	.....	.....	Hudson
The Pure Oil Co.	Nederland, Tex.	Wax Fractionation	200 bbls.	.....	Under Constr.	Sept., 1949	Texaco	Lummus	Lummus
Shamrock Oil & Gas Co.	Sunray, Texas	Increase Topping & Cracking Facilities	10,000 bbls.	$300,000	Under Constr.	3rd Qtr., 1949	U.O.P.	Staff	Staff
Shamrock Oil & Gas Co.	Sunray, Tex.	Gas-Compressor Unit	2900 hp.	$500,000	Under Constr.	July, 1949	.....	Staff	Staff
Shell Chem. Co.	Houston, Texas	Extend Acetone Facilities	.....	.....	Under Constr.	July, 1949	.....	Braun	Braun
Shell Oil Co.	Provident City, Tex.	Gas Stripping Plant	60,000 mcf	.....	Projected	1st qtr., 1950	.....	Staff, Fluor	Fluor
Shell Oil Co.	Notrees, Texas	Extension TXL Plant	30,000 mcf	.....	Under Constr.	Early 1950	.....	Brown & Root	Brown & Root
Shell Oil Co.	Denver City, Texas	Gas Compression, Absorp. Addition	30,000 mcf	.....	Under Constr.	Late 1949	.....	Fluor	Fluor
Sinclair Prairie Oil Co.	Midway Lane Field, Texas	Gas Compression	.....	.....	Under Constr.	Early, 1949	.....	.....	.....
Skelly Oil Co.	Skellytown, Tex.	Expand Gasoline Plant	.....	.....	Under Constr.	Fall, 1949	.....	.....	J. E. Carlson
Southern Minerals Corp.	Stratton Field, Texas	Gas Compression Addition	.....	.....	Under Constr.	1st Qtr., 1949	.....	.....	.....
Stanolind O&G Co., Opr.	Fullerton Field, Texas	Gasoline Plant	55,000 mcf	.....	Under Constr.	Jan., 1950	.....	J. & L. Constr.	J. & L. Constr
Stanolind O&G Co.	Brownsville, Tex.	Chemical Plant	.....	.....	Under Constr.	Jan. 1, 1950	.....	Badger	Badger
Stanolind O&G Co.	Levelland Field, Texas	Gasoline Plant	.....	.....	Under Constr.	1950	.....	Brown & Root	Brown & Root
Stanolind O&G Co.	N. Cowden, Tex.	Gasoline Plant	75,000 mcf	.....	Engineering	1950	.....	Stearns-Roger	Stearns-Roger
Sun Oil Co.	Starr Co., Texas	Gasoline Plant	35,000 mcf	$4 million	Under Constr.	August, 1949	Pet. Eng.	Pet. Eng.	Pet. Eng.
Sun Oil Co.	Jameson Field, Coke County Texas	Gasoline Plant	10,000 mcf	Part of $12 million	.....	Completed	.....	Pritchard	Pritchard
Tex. Natl. Gas Corp. & Slick-Urschc Oil Co.	Rankin, Tex.	Gasoline Plant	55,000 mcf	.....	Under Constr.	Late 1949	.....	Tex. Natl. Gas Corp.	Tex. Natl. Gas Corp.
The Texas Co.	Port Arthur, Texas	Lube & Wax Additions	†37,500 Crude ‡2,500 bbls. Oil	.....	Under Constr.	July, 1949	.....	Foster-Wheeler	Foster-Wheeler
The Texas Co.	Tijerina-Canales Field, Texas	Gas Compression	6000 mcf	.....	Under Constr.	Oct., 1949	.....	.....	.....
The Texas Co.	Chalk-Hill Field, Texas	Gas Compression, Absorp.	2000 mcf	.....	Under Constr.	August, 1949	.....	.....	.....
The Texas Co.	Withers Field, Tex.	Expand Compression	9000 mcf	.....	Under Constr.	July, 1949	.....	Tellepsen	Tellepsen
United Gas Co.	Carthage, Texas	2nd Gas Plant	100,000 mcf	$3.5 million	.....	Completed	.....	Hudson	Hudson
United Gas Pipe Line Co.	Karnes City, Okla.	Natural Gas & Condensate Processing Plant	10,000 mcf	$1 million	Under Constr.	Jan., 1950	.....	Delta	Delta
West Texas Gas Co.	Fritch, Texas	Enlarge Compressor Station	3150 Bhp	.....	Projected	Aug., 1949	.....	Staff	.....

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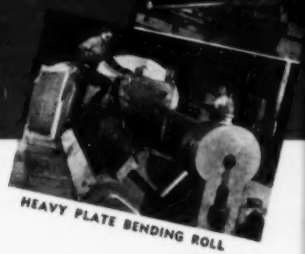
NATIONAL'S ANSWER...

to the World's Petroleum Needs



HEAVY PLATE BENDING ROLL

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Engineering and design is an important part of the services offered. Experienced engineers and draftsmen, as well as shop and fabricating personnel, are available, with modern facilities to carry out such programs.

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REFINERY COLUMNS
DEBUTANIZERS
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ABSORBER TOWERS
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DEPROPANIZERS
VACUUM STILLS
STABILIZER TOWERS

SPECIAL EQUIPMENT HAS BEEN INSTALLED TO INSURE QUICK DELIVERY OF ALL VESSELS:

- THREE 5-TON FLOOR CRANES
- FOUR 5-TON CAB TRAVELING CRANES
- SIX 10-TON CAB TRAVELING CRANES
- TWO 50-TON CAB TRAVELING CRANES
- 400-TON HYDRAULIC PRESS
- 10′ x 16′ HEAD AND PLATE FURNACE
- 7′ x 7′ x 40′ ANNEALING FURNACE
- 15′ x 15′ x 80′ ANNEALING FURNACE
- 2½″ CAPACITY PLATE BENDING ROLL
- X-RAY EQUIPMENT FOR PLATE UP TO 20″ THICK

The new plant, of more than 5 acres under one roof, is across the street from the present National Tank manufacturing site. *Inquiries for quick delivery are invited.*

A color brochure has been prepared describing in detail this new plant, which is located on a 36½-acre site. For your copy, please write

NATIONAL TANK COMPANY

TULSA, OKLAHOMA.

BUY . . . .

CALITE HEAT ENDURING CASTINGS

to

DEFINITE CHEMICAL AND PHYSICAL SPECIFICATIONS

This Will Assure Uniform Quality and Service

STANDARD SPECIFICATION NO. 10-38

Heat Enduring Castings
For Industrial Furnace Construction
Grade "F"

CHEMICAL COMPOSITION:

(a) The castings shall conform to the following requirements as to chemical composition:

	GRADE "F"
Chromium, per cent	25.0–28.0
Nickel, per cent	10.0–12.0
Manganese, per cent	0.50–1.25
Silicon, per cent	0.25–1.75
Sulphur, maximum per cent	0.05
Phosphorous, maximum per cent	0.05
Carbon	Within limits of Paragraph 4 (c)

(b) The chemical limits for all other added alloying elements, such as molybdenum, titanium and nitrogen, shall be specified by the manufacturer. The material shall conform therewith.

CREEP STRESS AND CERTIFICATE:

(a) The indicated creep rate of the material shall not exceed 1% in 10,000 hours when stressed by a tensile load not less than the following:

TEMP. °F.	STRESS PER SQ. IN. 1% CREEP IN 10,000 HOURS GRADE "F"
1400°	4200#
1500°	3700#
1600°	3200#
1700°	2600#
1800°	1950#

(b) Manufacturer shall submit standard creep data and residual physical properties made on material of his own manufacture and certified by an ACCREDITED LABORATORY. The chemical analysis of the creep test specimens shall be reported, including nitrogen content and any other special alloying elements.

TENSION TEST FOR DUCTILITY AFTER HEATING:

(a) Each heat shall conform to the following requirements as to tensile properties after the specimen has been subjected to a temperature of 1400° F. for 24 hours and furnace cooled to 400° F. Test shall be made at room tmperature.

	GRADE "F"
Tensile Strength, min.lb./sq.in.	80,000
Yield Strength, min.lb./sq.in.	35,000
Elongation in 2", min. per cent	9.0

Copy of complete specification will be mailed upon request.

THE CALORIZING COMPANY

HEAT ENDURING AND CORROSION RESISTING METALS.
CALITE ALLOY CASTINGS — CALORIZED STEELS.

WILKINSBURG STATION **PITTSBURGH 21, PA.**

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
ROCKY MOUNTAIN									
American Gilsonite Co.	Bonanza, Utah	Gilsonite to Crude Oil Pilot Plant	300 tons	$300,000	Engineering	July, 1949	.....	Staff	Staff
The Carter Oil Co.	Billings, Mont.	Crude Cat. Crk.	30,000 bbls.	$15 million	Under Constr.	3rd Qtr., 1949	.....	U.O.P., S.O.D., Fluor	Fluor
Continental Oil Co.	Billings, Mont.	Complete Ref. Cat. Crack	7,500 bbls.	$9.5 million	Under Constr.	Oct., 1949	U.O.P.	U.O.P., J. & L. Constr.	J. & L. Constr
Empire State Oil Co.	Thermopolis, Wyoming	Crude, Vacuum Units	5,000 bbls.	$325,000	Under Constr.	July, 1949	.....	Ref. Eng.	Ref. Eng.
Gulf Oil Corp.	Eunice, N. M.	Gasoline Plant	50,000 mcf			Completed	.....	Hudson	Hudson
New Mexico Asphalt Refg. Co.	Artesia, N. M.	Crude Unit	7,500 bbls.	$350,000	Under Constr.	July, 1949	.....	Geo. Armistead	Staff
The Pure Oil Co.	Worland, Wyo.	Gasoline Plant	.....	.....	Projected	.....	.....	.....	.....
Salt Lake Refining Co.	Salt Lake City, Utah	Capacity Increase	24,000 bbl.	.....	Planned	.....	.....	.....	.....
Shelly Oil Co.	Lea County, N. M.	Expanding Gasoline Plant	60,000 gals.	.....	Under Constr.	Mid 1949	.....	.....	J. E. Carlson
Texas Gulf Sulphur Co.	Worland, Wyo.	Sulfur Recovery Plant	30,000 mcf	.....	Projected	.....	.....	.....	.....
WEST COAST									
Barnsdall Oil Co.	Newhall, Calif.	Gasoline Recovery Unit	40,000 mcf	.....	.....	Completed	.....	Ref. Maint.	Ref. Maint.
General Petroleum Corp.	Torrance, Calif.	TCC Furnace Expansion	4,000 bbls.	.....	.....	Completed	.....	Staff-Lummus	Lummus
Hercules Powder Co.	Hercules, Calif.	Ammonia Plant	.....	.....	Under Constr.	Summer 1949	.....	Staff	Bechtel
Shell Chem. Corp.	Dominguez, Cal.	Add Acetone	.....	.....	Under Constr.	July, 1949	.....	Braun	Braun
Shell Oil Co.	Wilmington, Cal.	Extend Cracking Plant Compressors	.....	.....	Under Constr.	Middle 1949	.....	Fluor	Fluor
Shell Oil Co.	Wilmington, Cal.	Extend Tank Storage	.....	.....	.....	Completed	.....	Staff	Chicago Bridge & Iron Co.
Stancal Asphalt & Bitumicals Co.	Portland, Ore.	Asphalt Packing Plant, Warehouse	.....	.....	.....	Completed	.....	Staff	.....
Standard Oil Co. of Calif.	Bakersfield, Calif.	Crude Dist.	10,000 bbls.	$7.5 million	Under Constr.	Mid 1949	Braun	Braun	Braun
Standard Oil Co. of Calif.	Bakersfield, Calif.	Thermal, Crk., Gaso. Stabil. Gaso. Treating	9,000 bbls.	.....	Under Constr.	Late 1949	U.O.P.	U.O.P.	Braun
Standard Oil Co. of Calif.	El Segundo, Cal.	Cracked Naphtha Rerun Still	22,000 bbls.	$2.6 million	Under Constr.	Aug., 1949	.....	Braun	Braun
Sunset Oil Company	Los Angeles County, Calif.	Increase Topping Plant	†4000 bbls.	$150,000	.....	Completed	.....	Staff	Process Constr
Union Oil Co of California	Oleum, Calif.	Asphalt Refined Oil Loading Facilities	.....	$457,000	Under Constr.	Late 1949	.....	Early Constr.	Early Constr.
Union Oil Co. of California	Oleum, Calif.	Revision of Refining Facilities	.....	$4 million	Under Constr.	Late 1949	.....	Parsons, E. & A.	Ref. Maint.
Union Oil Co. of California	Oleum, Calif.	Improvements to Compound & Barrel Handling Facilities	.....	$1.5 million	Under Constr.	Late 1949	.....	Matthews Conveyor Co., J. M. Montgomery & Co.	Early, C. N., Peterson, Matthews Conveyor
Union Oil Co .of California	Oleum, Calif.	Duo-Sol Unit	6,000 bbls.	$3 million	Under Constr.	July, 1949	Max Miller	Max Miller	Max Miller
Union Oil Co. of California	Oleum, Calif.	Tankage and Utilities	.....	$1.8 million	Engineering	Late 1949	.....	Parsons	Eaton & Smith
Union Oil Co. of Calif.	Brea Olinda, Calif.	Enlarge Absorption Facilities	†6000 mcf	.....	Engineering	4th Qtr., 1949	.....	Parkhill-Wade	.....
FOREIGN									
Agwi Pet. Corp.	Fawley, Eng.	.....	120,000 bbls.	$140 million	Projected	1952	.....	.....	.....
Anglo-Iranian Oil	Abadan, Iran	Gas Plant	25,000 mcf	$2 million	Under Constr.	1950	.....	Badger	Badger
Anglo-Iranian Oil	Abadan, Iran	Cat. Cracker	30,000 bbls.		Under Constr.		.....	Foster-Wheeler	Foster-Wheeler
Anglo-Iranian Oil	Abadan, Iran	Solvent Dewaxing	400 bbls.	.....	Under Constr.	.....	Texaco	Badger	Badger
Anglo-Iranian Oil	Isle of Grain, Thames and Medway Estuary, Eng.	Wax Fractionation	60,000 bbls.	$120 million	Planning	1952	Texaco (Lube Unit)	Lummus	Lummus
Anglo-Transvaal Consolidated Investment Co.	Vall River Union, South Africa	Synthetic Gasoline and Diesel Oil Plant	.....	$50-60 million	Contracted	.....	.....	Hydrocarbon Research	.....
Arabian American Oil Co.	Abqaiq, Saudi Arabia	Crude Oil Stabilizer	300,000 bbls.	$4,800,000	Under Constr.	July-Sept., 1949	.....	Staff and Fluor	Staff and Fluor
Arabian American Oil Co.	Abqaiq, Saudi Arabia	Steam Power Plant, etc.	20,000 kw	$9,400,000	Under Constr.	July-Sept., 1949	.....	Staff and Fluor	Staff and Fluor
Arabian American Oil Co.	Ras Tanura, Saudi Arabia	Add Power Generating Unit	10,000 kw	$1,750,000	Under Constr.	July-Sept., 1949	.....	Staff and Fluor	Staff and Fluor
Arabian American Oil Co.	Ras Tanura, Saudi Arabia	Refinery Additions	.....	.....	Under Constr.	1949	.....	Bechtel	Bechtel
Australian Shell Oil Co.	Geelong, Victoria, Australia	New Refinery	.....	$4.8 million	Under Constr.	1951	.....	.....	.....
Azienda Generale Italiana Petroli	Rome, Italy	Add to Plant	24,000 bbls.	.....	Projected	.....	.....	.....	.....
*Atienda Generale Italiana Petroli	Palermo, Italy	Marine Fuel Plant	7,500 bbls.	.....	.....	.....	.....	.....	.....
Bahrein Pet. Co., Ltd.	Bahrein Island	Expansion Program	.....	$8.3 million	Under Constr.	Oct., 1949	.....	U.O.P., Bechtel	International, Bechtel, Inc.
Bahrein Pet. Co., Ltd.	Bahrein Island	Crude Still, Utilities	55,000 bbls.	$9.1 million	Planned	June, 1950	.....	Lummus, Bechtel	.....
British American Oil Co., Ltd.	Montreal, East P.Q., Canada	Ext. Cracking and Cat. Poly	13,300 bbls.	.....	Under Constr.	4th Qtr., 1949	Kellogg-U.O.P.	Kellogg	Kellogg
British Pet. Chem., Ltd.	Grangemouth, Scotland	Petro-Chem	.....	$20 million	Planned	.....	.....	S. & W. Badger	S. & W. Badger
Burmah Oil Co.	Burma	Furfural Plant Solvent Dewaxing, Wax Manufacturing Units	1,000 bbls.	$600,000	Designing	.....	Texaco	Badger	.....
Burmah Oil Co.	Syriam, Burma	Thermafor Clay Revivification	66 tons	$150,000	Design	1949	Max Miller, Socony-Vacuum	Max Miller	.....
California-Texas Co., Ltd.	Cartagena, Spain	Refinery	15,000-20,000 bbls.	.....	Proposed	March, 1951	.....	.....	.....
Caltex Pet. Maatschappij, N. V.	Rotterdam, Holland	Complete Refinery	20,000 bbls.	$18 million	Under Constr.	Feb., 1950	.....	McKee, Badger, U.O.P.	McKee

■ CONTINUED ON PAGE 94

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Cie. de Raffinage Shell-Berre	Berre, France	Capacity Increase	47,000 bbls.		Planned				
Cie. Francaise de Raffinage	Gonfreville, France	Furfural Refining, Solvent Dewaxing and Wax Fractionation Units	2,500 bbls.		Projected	1951	Texas		
Cie. Francaise de Raffinage	Gonfreville, France	Distillation Unit	20,000 bbls.		Under Constr.	1950		Foster-Wheeler	Foster-Wheeler
Cie. Francaise de Raffinage	Provence, France	Topping Unit	20,000 bbls.		Under Constr.	1950		Foster-Wheeler	Foster-Wheeler
Cie. de Raffinage Shell-Berre	Petit Couronne, France	Lube Unit			Planned				
Companhia Brasileira de Petróleos S.A.	Rio Grande, Brazil	Topping, Thermal Cracking	3000 bbls		Authorized	1952	Foster-Wheeler		
Compania Espanola de Petroleos S.A. (C.E.P. S.A.)	Canary Islands, Spain	Furfural Refining, Solvent Dewaxing, Wax Fractionation Units	5,000 bbls.	$4½ million	Under Constr.	Early 1950	Texaco, Standard, N.J.	Foster-Wheeler	Foster-Wheeler
Conselho Nacional do Petróleo	Mataripe, Bahia, Brazil	Thermal Cracking Refinery	2500 bbls.	$2.5 million	Under Constr.	Jan., 1950		Kellogg	Kellogg, Staff
Conselho Nacional do Petróleo		Thermal Cracking Refinery	45,000 bbls.		Design	1952			Fives, Lille, Schneider, Staff
Consolidated Ref., Ltd.	Haifa, Palestine	Crude Plant	80,000 bbls.		Planned	1950		Badger	Badger
Consolidated Ref., Ltd.	Haifa, Palestine	General Facilities			Under Design			Badger, Ltd.	
Consolidated Ref., Ltd.	Haifa, Palestine	Lube Plant	2,500 bbls.		Designing		Texaco, Juik	Lummus, Kellogg	Lummus, Kellogg
Creole Pet. Corp.	Amauy Bay, Venezuela	Crude Stills	60,000 bbls.	$175 million	Under Constr.	1951		S.O.D.	Foster-Wheeler, J. G. White
Creole Pet. Corp.	El Roble Field, Venezuela	Repressuring			Planning				
*Danish Government	Denmark	Refinery	21,000 bbls.		Planned				
Egyptian Government	Cairo, Egypt	Crude Plant						Lummus	Lummus
Excelsior Refineries	Lloydminster, Alberta, Canada	Moving Refinery	3000 bbls.	$500,000	Under Constr.	Sept., 1949	U.O.P.	U.O.P.	
Hi-Way Refineries, Ltd.	Saskatoon, Saskatchewan	Crude Topping Unit	2,000 bbls.		Under Constr.	Dec., 1949	U.O.P.	Ref. Eng.	Ref. Eng.
Hi-Way Refineries, Ltd.	Saskatoon, Saskatchewan	Thermal Cracking Unit	500 bbls.		Under Constr.	Dec., 1949	U.O.P.	Ref. Eng.	Ref. Eng
Imperial Oil, Ltd.	Edmonton, Canada	Increase Capacity	15,000 bbls.	$2½ million	Under Constr.	July, 1949		Staff, Barnes	Barnes
Imperia Oil, Ltd.	Ledue Field, Canada	Gas Absorption Plant	24,000 mcf	$6.5 million	Under Constr.	Middle 1950		Braun	Braun
Industrie Chimiche Italiane Petroli	Mantua, Italy	Crude	4,500 bbls.						
*Industria Nationale Petroli e Trasformazione	Massa Carrara, Italy	Refinery	40,000 bbls.						
*Italo-American Esso-Anic	Leghorn, Italy	Capacity Increase	28,700 bbls.						
*Italo-American Esso-Anic	Bari, Italy	Capacity Increase	38,300 bbls.						
Kuwait Oil Co.	Kuwait	Topping Unit	20,000 bbls.	$2 million	Under Constr.	July, 1949		Badger	Badger
*L'Alliance Petrolina	Antwerp, Belgium	Refinery	21,000 bbls.		Planned				
Mediterranean Ref. Co.	Trans-Arabian P.L. Mediterranean Term.	Refinery			"Paper Stage"				
Mene Grande Oil Co.	Puerto la Cruz, Venezuela	Refinery	30,000 bbls.						
National Oil Refineries, Ltd.	Llandarcy, Wales	Crude and Reform.	40,000 bbls.	$36 million	Designing			Badger	Badger
National Oil Refineries, Ltd.	Llandarcy, Wales	Furfural Refining, Solvent Dewaxing, Wax Fractionation Units	1,200 bbls.				Texaco	Badger	Badger
National Oil Refineries, Ltd.	Llandarcy, Wales	SO_2 Solvent Extraction	3,000 bbls.		Contracted			H. W. P.	
Pechelbronn S. A. E. M.	Merkwiller, France	Capacity Increase	1,550 bbls.		Authorized	1950			
Petro Carbon, Ltd.	Partington, England	Cat. Cracker Lube & Reform	20,000 bbls.						
Petro Chem., Ltd.	Partington, England	Petro Chemicals							
Petróleos Mexicanos	Poza Rica, Mex.	Gas Purification, Pressure Maintenance, etc.		$13 million	Contracted	Early 1950		McKee	McKee
Petróleos Mexicanos	Salamanca, Mex.	Crude, Gasoil, Cracking	30,000 bbls.	$12 million	Under Constr.	Early 1950	U.O.P.	McKee	McKee
Philblack, Ltd.	Avonmouth, England	Carbon Black Plant	50 million lbs. Yearly	$5 million	Contracted	1950	Phillips	H. W. P.	H. W. P.
Porto Marghera Rfg.	Venice, Italy	Enlarging Crude Unit			Contracted			H. W. P.	H. W. P.
Raffineries de Petrole de la Gironde	Ambes, France	Refinery	13,000 bbls.	$7.8 million	Under Constr.	Early 1950		U.O.P., McKee	McKee
Raffineries Francaises de Petrole de l'Atlantique	St. Nazaire, France	Consolidate Refineries	7,100 bbls.						
Raffineries di Napoli, S. P. A.	Naples, Italy	Topping Unit	10,000 bbls.		Under Constr.	Mid 1949		Staff	Staff
Raffineries di Napoli, S. P. A.	Naples, Italy	Solvent Treating	1,000 bbls.		Under Constr.	Early 1950	Texaco	Staff	Staff
Refinaria de Petróleo dó Distrito Federal S.A.	Rio de Janeiro, Brazil	Complete Refinery	10,000 bbls.		Authorized				
Refinaria e Explo-racao de Petróleo	Capuava, S. Paulo, Brazil	Thermal Cracking Refinery	20,000 bbls.		Authorized			Pan American Hydrocarbon Res., Inc.	Czech, Fact. Metal Work & Mech. Constr.
Richmond Exploration Co.	Lake Maracaibo, Venezuela	New Refinery	35,000 bbls.		Engineering	June, 1950			
Scottish Oil, Ltd.	Grangemouth, Scotland	Crude	28,000 bbls.	$28 million	Designing			Kellogg	Schneider
Scottish Oils, Ltd.	Grangemouth, Scotland	Cat. Crk.	5,000 bbls.		Planned				
Shell Chem. Corp.	Thornton, Eng.	Petro-chem		Several millions	Under Constr.	Aug., 1949			
*Shell Refining & Marketing Co. Ltd.	Stanlow, Eng.	Refinery Expansion	50,000 bbls.		Under Constr.				
Shell Ref. & Marketing Co. Ltd.	Shell Haven, England	Refinery Expansion	60,000 bbls.						
Shell Chem. Mfg. Co. Ltd.	Stanlow, Eng.	Petro-chem	80 tons			Completed			

• CONTINUED ON PAGE 96

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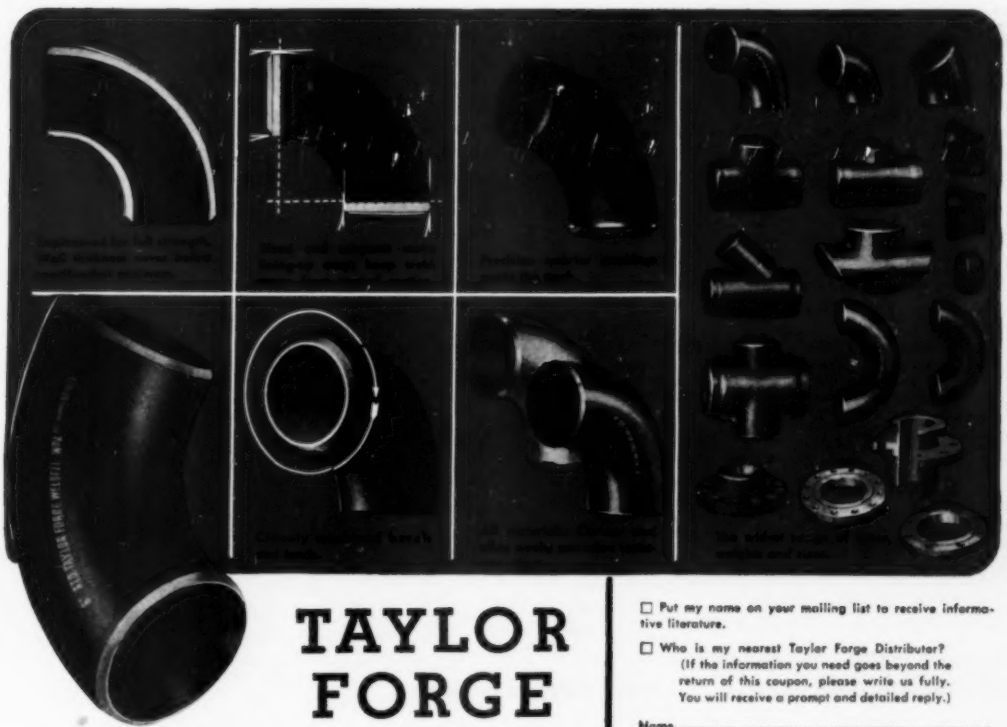

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REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Shell Oil Co. (Venezuela)	Puerto Cardon Venezuela	Complete Refg.	40,000 bbls.		Under Constr.	Mid 1950		Lummus	Lummus
Shell Ref. & Mark. Co., Ltd.	Heysham, Eng.	Remodel & Redesign Crude Plant	30,000 bbls.			Completed			
*Shell Oil Co. of Canada, Ltd.	Montreal, Canada	Refinery	27,000 bbls.		Under Constr.				Fluor, Ltd., McKee
*Shell Refining & Marketing Co., Ltd.	Hamburg-Harburg, Germany	Refinery	8950 bbls.		Under Constr.	Late 1949			
Société Generale des Huiles de Pétrole	L'Avera, France	LPG Units			Under Constr.	Mid 1950	Kellogg	Kellogg	Staff
Société Generale des Huiles de Pétrole	Dunkirk, France	Crude Reform.	33,000 bbls.		Under Constr.	Mid 1951	Lummus, Kellogg	Lummus, Kellogg	Lummus, Kellogg
Société Generale des Huiles de Pétrole	Dunkirk, France	Furfural Refining, Solvent Dewaxing, Wax Fractionation Units	2400 bbls.		Designing	Mid 1951	Texaco	Lummus	Lummus
Societe Industriel Belgique de Petrole	Antwerp, Belgium	Crude, Cracking Reforming	30,000 bbls.		Designing	Mid 1951			
Societa per Azioni Raffineria Padana Oli iMinerali	San Matrino di Trecate, Italy	Refinery	10,000 bbls.		Proposed				
Socony-Vacuum Francaise	Notre Dame de Gravenchon, France	Contact Plant			Under Constr.	Mid 1949		Staff	Staff
Socony-Vacuum Francaise	Notre Dame de Gravenchon, France	MEK Unit	1,000 bbls.		Design	Early 1950	Texaco	Lummus	Staff
Socony-Vacuum Francaise	Notre Dame de Gravenchon, France	Solvent Treating	1,100 bbls.		Design	Mid 1950	Jusk	Lummus	Staff
Socony-Vacuum Francaise	Notre Dame de Gravenchon, France	Furfural Unit	1,000 bbls.		Under Constr.	Mid 1949	Texaco	Staff	Staff
Socony-Vacuum Francaise	Notre Dame de Gravenchon, France	Grease and Compounding Plant			Under Constr.	Early 1950		Staff	Staff
Socony-Vacuum Francaise	Frontignan, France	Capacity Increase	13,500 bbls.		Under Constr.	Aug., 1949		Staff	Staff
Standard Française des Pétroles	Fort Jerome, France	Capacity Increase	30,000 bbls.		Authorized				
Standard Française des Pétroles	Fort Jerome, France	Dewaxing Plant	1,000 bbls.		Planned				
Standard Française des Pétroles	Fort Jerome, France	Deasphalting Plant	2,000 bbls.		Planned				
*Standard Oil Co., (N.J.)	Belgium	Refinery	33,000 bbls.		Planned	1953			
Stora Kopparberg S. Bergslags Co.	Gotheborg, Sweden	Crude, Ther. Cracking			Under Constr.	Spring, 1949		Lummus	Lummus
Trent Oil Prod. Development Co.	North Shields, England	Crude Plant	11,500 bbls.	$4 to $8 million	Plans approved				
Union Petrol Refinery, Ltd.	Johannesburg, Union of South Africa	New Refinery		$30 million	Projected				
Venezuela Gulf Refining Co.	Puerto la Cruz, Venezuela	Refinery	30,000 bbls.		Under Constr.	July, 1950		Lummus	Lummus
Venezuelan Pet. Co. (Sinclair)	Puerto la Cruz, Venezuela	Refinery	35,000 bbls.		Under Constr.			Frederick Snare Corp.	Frederick Snare Corp.
Yacimientos Petroliferos Fiscales	Buenos Aires, Argentina	New Refinery	28,000 bbls.		Engineering	Late 1950		Kellogg	Kellogg
Yacimientos Petroliferos Fiscales	La Plata, Argentina	Crude Topping, Gaso Treating	50,000 bbls.	$2.8 million	Under Constr.	Early 1949		Houdry Process Cat. Constr.	Cat. Constr
Yacimientos Petroliferos Fiscales Bolivianos	Sucre, Bolivia	Crude Plant	3,000 bbls.			2nd Qtr., 1949		Foster-Wheeler	Foster-Wheeler
YPF Bolivianos	Cochabamba Bolivia	Topping & Reforming Units	5,000 bbls.			1st Qtr., 1950		Foster-Wheeler	Foster-Wheeler

* First appearance in tabulation. † Added capacity.

Note—Badger—E. B. Badger and Sons. Barnes—W. M. Barnes & Co. Bechtel—Bechtel Corp. Bellows—W. S. Bellows Co. Braun—C. F. Braun Co. Brown Eng.—Brown Engineering Co. Brown & Root—Brown & Root Construction Co. Cat. Constr.—Catalytic Construction Co. Chem Constr.—Chemical Construction Co. Clarke—Clarke Construction Co. Delta—Delta Engineering Corp. Dresser—Dresser Engineering Corp. E. & A.—Ehrhart & Arthur, Inc. Fish Eng.—Fish Engineering Corp. Fluor—Fluor Corp. Foster-Wheeler—Foster-Wheeler Corp. Gaso. Plant—Gasoline Plant Construction Co. General American—General American Transportation Co. Houdry—Houdry Corp. Hudson—Hudson Engineering Corp. H. W. P.—Head Wrightson Processes, Ltd. Hydro Res.—Hydrocarbon Research, Inc. Ind. Eng.—Industrial Engineers, Inc. J. & L. Constr.—Construction Division, Jones & Laughlin Supply Co. Kellogg—M. W. Kellogg Co. Koch—Koch Engineering Co. Koppers—Koppers Co., Inc. Leonard—Leonard Construction Co. Lummus—The Lummus Co. Mason—Mason Brothers Construction Co. McKee—Arthur G. McKee Co. Max Miller—Max B. Miller & Co. Parsons—The Ralph M. Parsons Co. Pet. Eng.—Petroleum Engineering, Inc. Petro—Petroleum Rectifying Co. Pritchard—J. F. Pritchard Co. Process Eng.—Process Engineers, Inc. Process Constr.—Process Construction Co. Ref. Eng.—Refinery Engineering Co. Ref. Maint—Refinery Maintenance Co, Inc. Rust Eng.—Rust Engineering Co. S. O. D.—Standard Oil Development Co. State Eng.—State Engineering Co. Stearns-Roger—Stearns-Roger Manufacturing Co. Stone & Webster—Stone & Webster Construction Co. Tellepsen—Tellepsen Construction Co. Texaco—Texaco Development Co. U. O. P.—Universal Oil Products Co. Walco—Walco Engineering Wohfeld—Wohfeld Construction Co. Equally owned by California Texas Corp. and Socony-Vacuum Oil Co., Inc.

Construction Notes

Refinery Nears Completion For Petroleos Mexicanos

The $18 million refinery at Salamanca, Mexico, being built by Arthur G. McKee & Company for Petroleos Mexicanos, will be 90 percent complete by October 1. A refinery steam plant and crude distillation unit will be finished by February or March, 1950. The crude distillation unit will have a daily capacity of 30,000 barrels. Other equipment to be installed are a continuous treating plant, a kerosine treating plant, Ethylizing station and LP-Gas plant. Repair and maintenance of all company tank cars will be in the tank car repair shop being built on the refinery site.

Conoco Starts Building

Continental Oil Company has started construction on a natural gasoline plant in Starr Couty, Texas. Gas processing facilities will be increased from 13 million to 20 million cubic feet daily. Estimated to cost $1½ million, the plant will also produce approximately 5800 gallons of butane and 25,000 gallons of gasoline and will return 8¼ million cubic feet of gas to five main reservoirs daily. Completion is scheduled for late 1949.

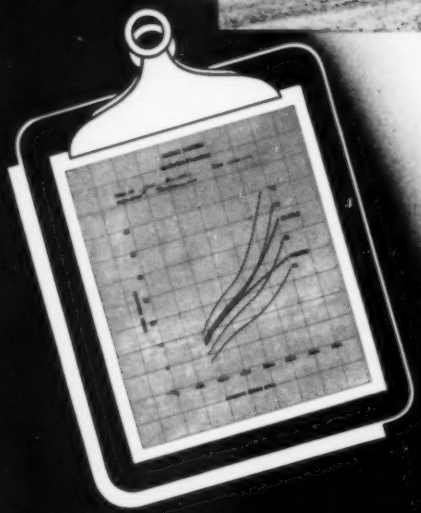
Deep Rock to Modernize Cushing, Okla., Refinery

A modernization and expansion program, under way at the Deep Rock Oil Corporation refinery, Cushing, Okla., includes a new crude battery, feed preparation unit, heavy oil vis-breaker, gas recovery plant and enlarged polymerization plant. Auxiliary equipment such as an enlarged boiler house, cooling towers and water supply also are planned as are a new research and development laboratory and office building.

Universal Oil Products Company designed the unit and Jones & Laughlin Supply Company has been awarded the contract for construction. Completion is scheduled during the spring of 1950.

DUPONT TETRAETHYL
LEAD COMPOUNDS

Fleet of antiknock rating cars from the East Coast Road Test Laboratory enroute to testing area.



Drivers compare notes between test runs.

Du Pont Research

Road Testing for Fuel Performance

Combustion knock is one of the most important factors limiting development of improved engines. While laboratory test methods provide a measure of fuel knocking characteristics, the final criterion of a fuel's worth is its performance in a car on the road. For that reason, road testing plays an important part in the Du Pont research program on tetraethyl lead and other antiknock agents.

To provide a complete evaluation of fuels and additives under a wide variety of road conditions, Du Pont maintains road testing facilities on both the East and West Coasts. Cars of the East Coast Laboratory weekly roll up thousands of miles studying fuel performance in both stock passenger cars and cars equipped with experimental high compression ratio engines.

The Road Test Laboratory is used by Du Pont to evaluate motor car fuel needs and to proof-test the experimental additives which come from chemical research. This is research aimed at helping you produce better fuels—today and in the future.

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

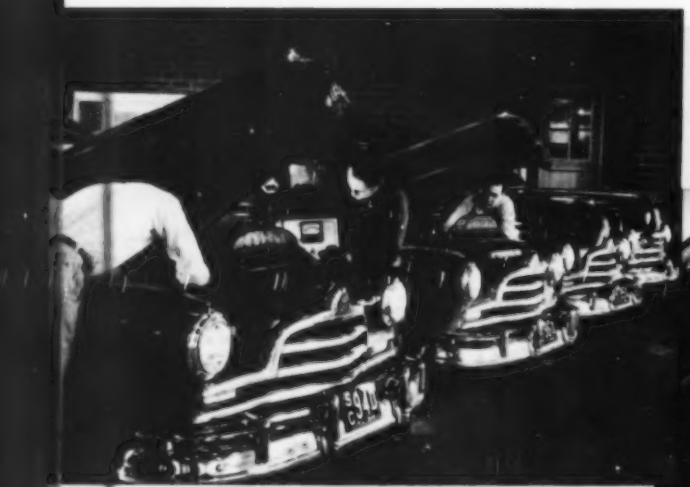
Measuring

Fuel Performance in Today's and Tomorrow's Engines

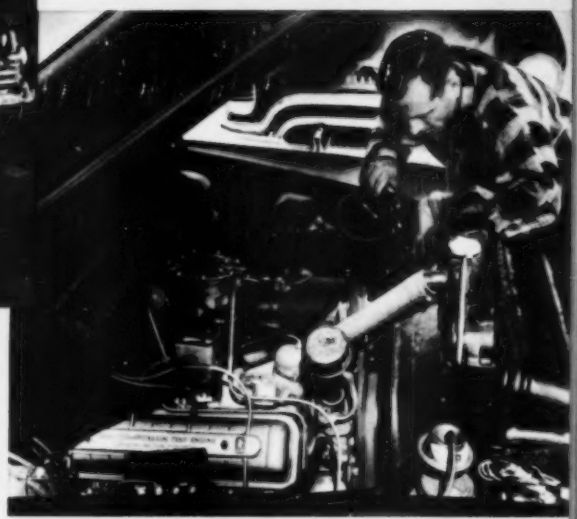
It is well known that fuels of different chemical types have markedly different "octane numbers" under different engine conditions. When compared with laboratory ratings, some fuels appreciate in octane value on the road while others depreciate. The numerous factors affecting fuel performance such as operating conditions, vehicle and engine design and many others are being investigated by the East Coast Laboratory through extensive road anti-knock and endurance testing.

Another project is an investigation of the effect of experimental high compression ratio research engines on fuel performance. These are installed in test cars and are being used in the study of fuel requirements.

Information developed through road testing will contribute to improved additives and fuels, today and in the future.



For comparative service and endurance tests on fuels identical cars are used. Here a group is being serviced prior to a run.



In addition to stock passenger cars, cars equipped with experimental high compression ratio research engines are used to study fuel performance. This 10 to 1 ratio engine is being checked during a road test.

MAKE DU PONT THE SOURCE FOR ALL OF YOUR GASOLINE ADDITIVES . . .

Tetraethyl Lead Compounds
Motor Mix—Aviation Mix
Antioxidants
Metal Deactivator — Dyes

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Better Things for Better Living . . . *Through Chemistry*

E. I. DU PONT DE NEMOURS & COMPANY (INC.)
PETROLEUM CHEMICALS DIVISION
Wilmington 98, Delaware

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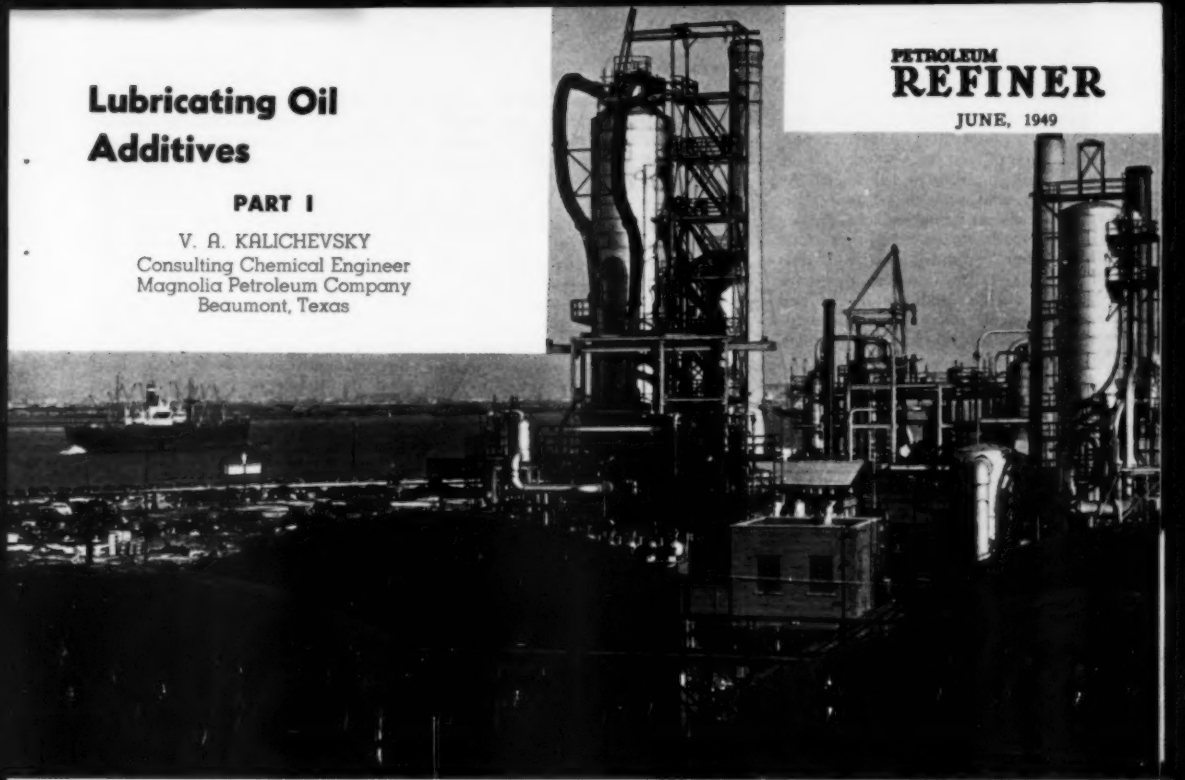
District Offices: Wilmington, Del. · Chicago, Ill. · Tulsa, Okla. · Houston, Texas · Los Angeles, Calif.

PETROLEUM
REFINER
JUNE, 1949

Lubricating Oil Additives

PART I

V. A. KALICHEVSKY
Consulting Chemical Engineer
Magnolia Petroleum Company
Beaumont, Texas



Socony-Vacuum Oil Company, Inc.'s Paulsboro, N. J., plant where the tube still, on the right, the first continuous atmospheric combination tube still built in this country, was erected in 1926-27. At left is a later and much larger unit. In background is a solvent extraction unit for lubricating oils manufacture.

***ADDITIVES** are of increasing importance in the manufacture of lubricating oils. In prominent commercial use since the late 30's, additive formulations now are employed to improve several of the natural properties of petroleum lubricants—pour point, viscosity index, oiliness, stability in service, color and fluorescence, foaming tendencies and rust preventive characteristics.*

A recognized authority in this field, the author of this series makes an outstanding contribution to the literature pertaining to additives in this comprehensive survey which also lists existing patent literature. Patents are classified in a number of convenient tables, greatly facilitating the matter of locating desired information. For example, the pour point depressants are subdivided into metallic compounds, polymers and auto-condensation products, etc. Individual compounds are listed alphabetically with reference to U. S. patent numbers, dates and inventors.

This series should be highly valuable to technologists working in the lubricating oil field, since the important material herein is not available in such extensive form in a single grouping.

LUBRICATION was not an important problem even as late as a century ago when the beginning of the "Industrial Age" in the modern meaning of these words, was still in the dim future. The wear and tear of the contemporary slow moving machinery could be prevented for all practical purposes by the use of almost any kind of available material that would form a protective layer between the revolving parts of crude mechanisms which at that time represented the last word in engineering and science. No experts were needed to solve the difficulties and the necessity of having a well trained technical personnel to keep the engines in good working order had not yet been felt.

At the time the oil industry was born this state of affairs still prevailed. Crude petroleum residues or heavy distillates were quite satisfactory for meeting the current lubrication problems. A light treatment with sulfuric acid, clay or some of the other common chemicals was all that was needed to impart to them the additional stability in service and to give a pleasant appearance which gratified the esthetic demands of the most discriminating customers. Only too often some imaginary and even harmful specification was attached to the product. The science of lubrication was not yet understood and found no practical application.

With the development of modern machinery, operating at high temperatures and pressures and often in the presence of air, water or other oxidizing and corrosive agents, the requirements imposed on good lubricants were greatly stiffened. Further mechanical progress became dependent on the availability of lubricating agents capable of withstanding the extremely severe service conditions. Petroleum products had to be refined with considerable care but it was soon discovered that even by adjusting the treating procedures so as to obtain optimum improvements in their properties, the resulting materials were not always capable of the desired performance. Other means had to be found to overcome the obstacles. This was achieved by the introduction of additives.

Experimental work showed that the

presence of small or even minute quantities of some substances in oils may have a profound effect on their properties. This offered a new method of improving qualities of lubricants. As the work went on such substances began to assume progressively greater importance in formulating high grade lubricating oils and the oil itself thus began to be considered as a carrier for the various addition agents and not as the all important element for the solution of lubrication problems.

These new developments had a profound effect on refinery operations. It was soon found that the depth of refining had a direct influence on the so-called inhibitor response or the degree of effectiveness of the addition agents. The oil treated under optimum conditions to secure its best performance as a lubricant in the absence of these agents was not the best product to use in their presence. In general, additives are most effective when used in oils of more or less homogeneous composition. Heavily refined oils are more paraffinic in nature than the lightly refined ones from which not all the impurities or aromatic types of compounds have been eliminated. For this reason their additive response is usually better. At the same time, such heavily refined oils in the absence of additives are frequently less stable in service than the lightly treated ones.

A lubricating oil additive must meet a number of requirements before it is released for commercial use. It must be economical. It must also be compatible with other additives which the oil may contain. If some other brand of oil is used in an engine in case of emergency or by error, additives present in such oils must also be compatible. The additive used for improving one of the oil properties should have no deleterious effect on some other property. For these reasons a tremendous amount of experimental work is required before the additive is released to the trade. This necessitates a large expenditure of both time and money.

An additive may improve one or several properties of an oil. The first type of additives is often referred to as unifunctional and the second type as multifunctional. Theoretically maximum efficiency can be obtained by the use of unifunctional additives provided the amounts used are carefully adjusted for every batch of oil. This is not always feasible in commercial practice. Besides handling of a large number of additives is inconvenient and introduces another source of possible error. For these reasons, multifunctional additives or equivalent blends of unifunctional additives are often employed. However, the discussion below is restricted mainly to the unifunctional additives for the purpose of clarity.

The use of additives in lubricating oils is relatively new. Except for a few isolated instances, their commercial use on a more or less wide scale began in the early 30's and they gained their present prominence about a dozen or so years ago. During this time a considerable number of substances appeared on the market which were designed to improve many of the oil properties. They may be classified as follows:

1) Pour point depressants
2) Viscosity index improvers
3) Oiliness carriers
4) Oxidation inhibitors and detergents
5) Dyes
6) Anti-foam agents
7) Rust preventatives

Many of these groups of additives may be subdivided into subgroups which are discussed in greater detail below. Hamilton and Keyser[1] present a very complete picture on the use of these substances in commercial practice and the reader is referred to their article for additional information on the subject.

1. *Pour Point Depressants*

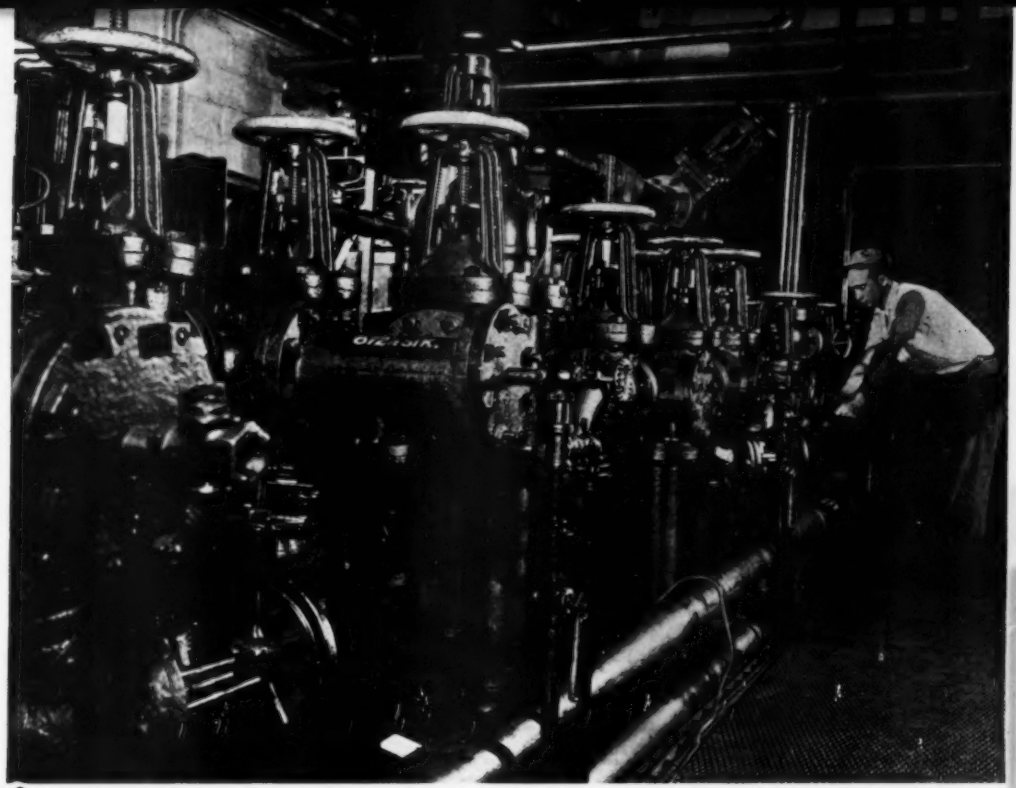
The presence of wax in lubricating oils is not objectionable provided it remains liquid and does not congeal. Under these conditions it may even be beneficial by slightly raising the viscosity index of the oil, apparently due to the dilution effects described further below in connection with the viscosity index improvers, and by lowering somewhat, the carbon residue. This latter effect is also explained as a dilution phenomena because the carbon residue of the wax is nil. The effect of wax on flash and fire tests and on oiliness is usually insignificant while its effect on oxidation characteristics depends to some extent on the type of oxidation test employed and might be shown to be in either direction.

The above shows that if the wax can be made to stay in the oil without affecting the oil mobility it would become a desirable rather than an undesirable component. Furthermore, removal of wax by conventional dewaxing methods is expensive, particularly if the fluidity of the oil must be maintained at low temperatures which requires cooling the oil to very low temperatures before filtering or centrifuging the solidified wax.

Congealing characteristics of an oil are usually determined by the pour point test. These characteristics depend on the size, form and rate of formation of wax crystals which, in their turn, frequently depend on the previous history of the sample. Because of these complications it is highly important that the pour test determinations are carried out by following every detail of the standardized procedure. Heating the oil before testing may cause a change not only in the pour test of the oil but also in its specific gravity and viscosity. All these three properties may be raised or lowered depending on whether cooling takes place with the oil at rest or in motion. They are usually raised or remain unaltered if cooling is accompanied by stirring and lowered if the cooled sample is held at rest. These changes are often observed with the Pennsylvania type of oils but they occur also with Mid-Continent stocks which contain both wax and asphalt. It is of interest in this connection that distillate fuels are, in general, not temperature sensitive with respect to their ASTM pour test, while residual fuels often give different results when preheated to various temperatures. Moerbeek and van Beest[2] showed that addition of small quantities of asphaltenes to a residual oil, the pour point of which was insensitive to the temperature of pretreatment, increased the sensitivity of this fuel to the pour test. On the other hand, removal of asphaltenes from fuel oils, which are in themselves sensitive with respect to their pour points, made them insensitive to temperatures of pretreatment.

The fact must not be overlooked that pour test is quite an arbitrary measure of the congealing point of the oil even if all necessary precautions are observed in the testing procedure. These precautions are important only for obtaining comparable and reproducible results. An oil which will not flow in a small vessel may be quite fluid when placed in a large container. In general the high pour test is not necessarily associated with the difficulty of starting an engine, but is undesirable as the flow of oil from the oil sump to the pump intake is slowed down. This results in excessive wear of moving parts before the oil is sufficiently heated to become fluid. On the pressure side of the system the flow will usually be satisfactory even with relatively high pour test oils, provided the pump can take suction.

While pour test is commonly associated with the presence of wax, it must not be overlooked that even the completely dewaxed oils still have a pour point caused by the loss of fluidity of the oil itself at low temperatures. This pour point is sometimes referred to as



Manifolds in rear of Socony-Vacuum's Paulsboro plant are used to divert finished oils to the compounding department.

"viscosity pour." It is often observed even at relatively high temperatures with oils containing both wax and asphalt. Removal of wax alone will not lower the pour point below a certain level. Further lowering is obtained, however, by removing the asphalt.

The possibility of discovering substances which are capable of lowering the pour point of oils without removing the wax has been indicated by the effect of some of the oil constituents of asphaltic nature on the improved fluidity of such wax-bearing stocks at low temperatures. Unfortunately, the presence of these constituents in finished products is objectionable because of their instability. Likewise, the amount which must be added to the oil to affect the pour point is considerable.

Such observations stimulated the desire of finding chemical substances which would be capable of lowering the pour point of an oil without imparting to it the undesirable properties. A large number of them have been discovered and patented, as shown in Table 1. (See Appendix.) Some of these pour point depressants are multi-functional additives which may be seen from their chemical structure. The best known commercial products are Santopour, Paraflow and Acryloids. They are available in several grades and their physical properties are presented in Table 2. (See Appendix.)

Recommendations were also made for preparing pour point depressants by reacting the high pour point oils with certain chemicals as shown in Table 3. (See Appendix.)

The pure pour point depressants are very viscous substances which are normally diluted with oil before they reach the market in order to facilitate handling and blending operations. They are added to the oil in very small quantities, normally 0.5 percent or less. In these and somewhat higher concentrations they have no unfavorable influence on the various oil properties unless the amount added is considerably above the permissible economic limits. Thus the increase in the carbon residue of the oil and the rate of carbon formation in the engine may be noted if the quantity of Paraflow added is 2 percent or more[3] which is much greater than normally employed.

The pour point depressants are added to oils which are usually partially dewaxed. This increases considerably their effectiveness and insures their most economic use. For instance, the stock may be dewaxed to a pour point of about 20° F. and the pour depressant added to lower it to 0° F. or below. In general, the synthetic pour point depressants are particularly effective with highly refined oils containing a large amount of readily crystallized wax. Pour point of such oils may be reduced as much as 50° or 60° F. by the addition of small quantities of such substances.

It is of interest that the pour point depressants themselves have a relatively high pour point and when they are added to a wax bearing oil the pour point of the blend is first lowered and then shows a gradual increase. Similarly, if they are added to a wax free distillate the pour point increases instead of decreasing. This shows the existence of an optimum ratio between the pour point depressant and wax in the oil which produces the lowest possible pour point of the blend.

The beneficial action of pour point depressants is explained by their ability of inhibiting the excessive growth of wax crystals and of changing their shape from the needle type to small equiaxial grains of uniform size.[4] However, the mechanism of their action does not seem as yet, to be completely clarified. For instance, it is somewhat

Part of operation to repair and rehabilitate lubricating oil drums for re-use at Socony-Vacuum's Paulsboro plant.

difficult to explain why in some instances, addition of a small quantity of wax with a pour point depressant reduces the pour point of the oil to a greater extent than the addition of the pour point depressant alone.[5] With some oils the addition of pour point depressants has at first no action on their pour point which begins to change only after the quantity of depressant added is raised above a certain minimum. Certain pour point depressants, such as aluminum stearate, may create in some instances, a "maximum" and a "minimum" pour point which can be eliminated by the addition of triethanolamine.[7] The complexity of the reactions involved in all these phenomena thus becomes apparent.

The quantity of the pour point depressant needed, varies both with the nature of the oil and the nature of the additive. Some of them may be more effective in low concentrations while others exhibit their maximum efficiency at high concentrations. While the pour point depressants have a very beneficial effect on improving fluidity of oils at low temperatures, the cloud point of the oil is affected to a much lesser extent. Although the cloud point has no effect on performance of the oil in service, it is objectionable from a sales viewpoint. Addition agents were suggested for lowering the cloud point of the oil but as yet they are not in commercial use.

Some of the oils containing pour point depressants may show an increase in pour point test on storage during the winter. The greatest increase in pour point occurs when daily temperatures fluctuate somewhere just above the pour point of the oil. This phenomenon is known as pour point reversion.

A considerable amount of work has been done in connection with this problem.[6] Pour point reversion was found to occur only in storage—not in service—and the greatest rise in pour point is observed when rapid warming up period is followed by a sharp fall in temperature.

The present explanation of pour point reversion assumes that the pour point depressant redissolves in the oil before the wax goes into solution. The wax crystals are thus freed from the enveloping film of the pour point depressant. On subsequent cooling, additional quantities of wax are deposited on these crystals which grow in size, before the pour point depressant is able to form a protective film. As a result the pour point of the oil rises after each warming up and cooling cycle. Although this theory might be modified in order to explain all the encountered phenomena, it seems to be the best one so far advanced.

Pour point reversion depends on a number of variables such as type and relative quantities of neutral and residual oils in the blend, nature of wax associated with the oil, particularly the high melting point wax responsible for cloud formation, extent of wax removal, amount and type of pour point inhibitor employed, and presence of other additives in the oil. In order to combat the problem successfully, new pour point depressants were developed, such as Santopour B or Paraflow 46, which eliminate the difficulty when they are properly applied to the oils.

Besides their use for lowering the congealing temperature, the pour point depressants may also be employed for improving dewaxing characteristics of oils. When applied in this manner they are usually referred to as dewaxing assistants, wax modifiers or crystallization regulators. It is well known that refining of oils with chemicals often improves their dewaxing characteristics, a phenomenon usually ascribed to the removal of inhibitors. Similar control may be obtained by adding pour point depressants to oils to be dewaxed in order to secure the desired balance. The two methods are somewhat contradictory and no satisfactory explanation for reconciling the mechanism of the involved phenomena seems to be available. Besides their direct influence on the crystal structure of the separated wax, some of the dewaxing assistants may act also as crystalization centers or filter-aids thus enhancing their beneficial crystal modifying action in the dewaxing operations. Various substances suggested for use in connection with the different dewaxing processes are shown in Table 4. (See Appendix on pages following.)

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[2] Moerbeck, R. H. and van Beest, A. C., Oil and Gas J. **33**, No. 42 33-4 (1935).

[3] Suida, H. and Poll, H., Petroleum Z., **29**, No. 23, Motorenbetrieb Maschinen-Schmierung **6**, No. 6, 2-4 (1933).

[4] Davis, G. H. B., Natl. Petroleum News, **24**, No. 52, 32, 34 (1934).

[5] Ravikovich, A. M., Neftyanoe Khoz, 1937, No. 10, 65-9. See also Lieber, E., Lubrication Engineering, Mar. 1946, describing various theories advanced to explain the mechanism of pour point depression of oils by the use of additives.

[6] Henderson, L. M. and Annabel, W. G., Oil Gas J. **42**, No. 18, 54-6, 59 (Sept. 9, 1943); Hodges, C. E. and Boem, A. R., Oil Gas Jr., **42**, No. 7, 103-6 (June 24, 1943); Hodges, C. E. and Rogers, D. T., Oil Gas Jr., **46**, No. 22, 89-93, 99 (Oct. 4, 1947).

[7] Kaladzhal, R., Neftyanoe Khoz., **26**, No. 4, 40-4 (1934).

APPENDIX

TABLE 1
Pour Point Depressants—A. Metallic Compounds

COMPOUND	U.S. Patent	Date	Inventor
Aluminum soaps of acids from oxidized paraffin wax.	2,059,192	11/ 3/36	Barth, E. J. and Corlew, R.P.
Aluminum stearate	1,820,295 1,896,342	8/25/31 2/ 7/33	Bennett, H. T. Bennett, H. T. and Story, L.G.
Aluminum stearate or palmitate and sodium or tin sulfonate.	2,308,116	1/12/43	Silverman, I
Aluminum stearate and a reaction product of phosphorus pentasulfide and a petroleum mahogany sulfonate.	2,423,789	7/ 8/47	Murphy, T. G. and Faust J.
Barium or calcium phenolates of wax-phenol disulfide.	2,366,874	1/ 9/45	Reiff, O. M.
Barium calcium or zinc salts of alkyl substituted aromatic carboxylic acids.	2,393,934	1/29/46	Reiff, O. M. and Andrew, H. J., Jr.
Metal salts of alkyl-substituted aromatic-aliphatic carboxylic acids.	2,198,275	4/23/40	Reiff, O. M., Otto, F.P., Giammaria, J. J. and Oberright, E. A.
Metal salt of an acidic phosphorus and sulfur containing reaction product.	2,388,199	10/20/45	Williams, R. H. and Fuller E. W.
Metal salts of ester type waxes treated with a sulfide of phosphorus.	2,383,495	8/28/45	Musselman, J. M.
Metal salts of hydroxy-aromatic-aliphatic carboxylic acid.	2,198,274	4/23/40	Reiff, O. M. and Otto, F.P.
Multivalent metal salts of alkylated aromatic acidic compounds reacted with hydrogen sulfide.	2,401,273	5/28/46	Reiff, O. M. and Andrus, D. W.
Multivalent metal salts of substituted aromatic compounds reacted with mercaptothiazoles.	2,392,766	1/ 8/46	Reiff, O. M.
Sodium, ammonium or hydrogen polysulfides and chlorinated petrolatum.	2,341,453	2/ 8/44	Lieber, E. and Dean, R. M.
Sodium amylate and an alkaline-earth organoborate.	2,341,565	2/15/44	Lyman, A. L. and Mulit, L. H.
Sodium or potassium phenates and chloroform.	2,383,869	8/28/45	Lieber, E. and Dean, R. M.
Stannous stearate	2,306,017	12/22/42	Faust, J.
Sulfides, selenides or tellurides of alkyl substituted aryl metal oxides.	2,366,873	1/ 9/45	Reiff, O. M.
Tin or cobalt salts of phthalyl ester of wax-phenol carboxylic acid disulfide.	2,355,240	8/ 8/44	Reiff, O. M.
Titanium stearate	2,055,417	9/22/36	Moser, F. R.
Wax - phenoxy - aliphatic metal carboxylates or alkyl-substituted aryl ether carboxylic acids.	2,252,665-6	8/12/41	Reiff, O. M. and Otto, F. P.
Wax-substituted and carboxylated metal phenoxides.	2,252,662-3	8/12/41	Reiff, O. M.
Zinc or magnesium salts of acids from oxidized paraffin wax.	1,789,026	1/12/31	Sullivan, F. W., Jr.

TABLE 1
Pour Point Depressants—C. Polymers and Auto-Condensation Products

Starting Material	U.S. Patent	Date	Inventor
Acid halides of naphthenic acids	2,246,312	6/17/41	Lieber, E.
Aliphatic-2, 5-pyrrolidine-diene compounds containing dimethylene groups.	2,370,943	3/ 6/45	Dietrich, M. A.
Aromatic compounds	2,384,107	9/ 4/45	Lieber, E.
Chlorinated stearone	2,238,638	4/15/41	Gleason, A. H.
Cracked residuum	2,225,430	12/17/40	Fulton, S. C.
Cracking tar	2,114,467	4/19/38	Fulton, S. C. and Whiteley, J. M.
Chloro or dichloro pentane	2,327,535	8/24/43	Lieber, E. and Rice, H. T.
Ethers	2,245,639	6/13/31	Bartlett, J. H. and Zadde, A. J.
Glycerol	2,344,565	11/16/44	Lieber, E. and Thorner, M. E.
Halogenated hydrocarbons	2,087,682	7/20/37	Davis, G. H. B. and Swope, C. C.
Heptadecyl phenyl ketone	2,307,891	1/12/43	Lieber, E.
Hydrocarbons rich in paraffin	2,062,354	12/ 1/36	Davis, G. H. B.
Ketones	2,407,087	9/ 3/46	Lieber, E. and Cashman, A. F.
N-octadecylacrylamide	2,387,501	10/23/45	Dietrich, M. A.
Octadecanediol	2,111,760	3/22/38	Graves, G. D.
Olefins	2,379,728	7/ 3/45	Lieber, E. and Rice, H. T.
Oleic alcohol	2,020,703	11/12/35	Schumann, C. and Ufer, H.
	2,020,714	11/12/35	Wulff, C and Breuers, W.
Organic materials (subjected to a high tension electric discharge).	2,201,767-8	5/21/40	Franceway, J. A., Jr. and Davis, G. H. B.
Phenanthrene	2,121,326	6/21/38	Pevere, E. F.
Phenyl oleate	2,300,131	10/27/42	Mikeska, L. A.
	2,239,533	4/22/41	Mikeska, L. A.
Phenyl stearate	2,281,942	5/ 5/42	Lieber, E.
Rubber	2,211,442	8/13/40	Steffen, E. M.
Soybean oil	2,365,919	12/26/44	Uloth, R. and Mueller-Conradi, M.
Stearyl chloride	2,251,550	8/ 5/41	Lieber, E.
	2,308,184	1/12/43	Lieber, E.
Waxes (subjected to a silent electric discharge)	2,073,641	3/16/37	Liberthson, L.
	2,197,768-9	4/23/40	Pier, M. and Christmann, F.
	2,376,807	5/22/45	Pier, M. and Christmann, F.
Wool fat	2,023,369	12/ 3/35	Limburg, H.

TABLE 1
Pour Point Depressants—B. Non-Metallic Organic Compounds

COMPOUND	U.S. Patent	Date	Inventor
Acetylated resins	2,393,181	12/15/46	Mikeska, L. A.
Acetyl stearyl naphthalene	2,268,410	1/30/41	Lieber, E.
Acylated coumarone*	2,197,712	4/12/40	Ralston, A. W. and Hoffman, E. J.
Acylated indene*	2,197,713	4/12/40	Ralston, A. W. and Hoffman, E. J.
Alkyl substituted amino aryl hydroxides.	2,367,377	1/16/45	Reiff, O. M.
Alkyl substituted hydroxy-aromatic carboxylic acids.	2,253,811	8/26/41	Reiff, O. M.
Amides of alkyl substituted aromatic carboxylic acids.	2,393,934	1/29/46	Reiff, O. M. and Andrews, H. J., Jr.
Benzyl chloride	916,506	4/27/09	Whitney, W. R.
Cellulose stearate	2,115,823	5/ 3/38	Miller, F. L. and Winning, C.
Chlorinated heptadecyl naphythyl ketone.	2,315,063	3/30/43	Lieber, E.
Compounds consisting of an alkyl group and an ether carboxylic acid group interconnected by sulfur, selenium or tellurium atoms.	2,326,496	8/10/43	Reiff, O. M.
Dimethyl naphthalene and an aromatic polymer.	2,079,782	5/11/37	Wiezevich, P. J.
Esterified hydrostearic acid	2,031,227	2/18/36	Pevere, E. F. and Ludeman, C. G.
Etherified or esterified phthaleins and sulfone-phthaleins.	2,382,730	8/14/45	Lieber, E.
Glycerol tristearate	2,119,718	6/ 7/38	Pevere, E. F.
Lignin ester	2,410,578	11/ 5/46	Giammaria, J. J.
Mannitan tetrastearate	2,138,771	11/29/38	Pevere, E. F.
Mixed ketones	2,033,543	3/10/36	Ralston, A. W. and Christensen, C. W.
Monoamino amide of oleic acid	2,342,114	2/22/44	Blair, C. M., Jr.
Monosulfides of alkyl substituted hydroxy aromatic hydrocarbons.	2,350,368	6/ 6/44	Reiff, O. M.
Octadecyl phthalate or mellitate	2,199,187	4/30/40	Rosen, R.
Oleyl alcohol ester	2,342,113	2/22/44	Blair, C. M., Jr.
Para-cymene-2	2,203,044	6/ 4/40	Brown, T. J.
Phosphite esters of paraffin wax-phenol disulfide.	2,368,598	1/30/45	Reiff, O. M.
Polyesters of polyhydroxy aliphatic alcohols.	2,254,433	9/ 2/41	Lieber, E.
Rufigallic acid hexastearate, pyrogallol tristearate, resorcinol distearate and allied substances.	2,053,853 2,073,080	9/ 8/36 3/ 9/37	Van Peski, A. J. Van Peski, A. J.
Tetralin naphthalene ketone	2,249,564	7/15/41	Lieber, E.
Tetranaphthyl	2,164,780	7/ 4/39	Pevere, E. F.
Wax-hydroxyphenyl stearic acid	2,316,889	4/20/43	Reiff, O. M., Otto, F.P., Giammaria, J. J. and Oberright, E. A.
Xylylstearamide	1,870,074	8/ 2/32	Sullivan, F. W., Jr. and McGill, W. J.

* These additives are described by the inventors in considerable detail in National Petroleum News, April 19, 1939, R150-4.

TABLE 1
Pour Point Depressants—D. Substances of Indefinite Composition

Substance or Reacting Materials	U.S. Patent	Date	Inventor
Acids from oxidized wax	2,118,915	5/31/38	Butz, R. J. and Cantelo, R. C.
Acylated reaction product of an aromatic hydrocarbon and a chlorinated aliphatic hydrocarbon.	2,147,547	2/14/39	Reiff, O. M. and Badertscher, D. E.
Acylated reaction product of phenol and chlorinated wax.	2,138,809	11/29/38	Reiff, O. M. and Badertscher, D. E.
Acylated synthetic resin containing ring structure.	2,429,479	10/31/47	Mikeska, L. A.
Adipic acid, chloride and a petroleum fraction.	2,268,409	12/30/41	Lieber, E.
Aliphatic alcohols and aromatic compounds.	2,273,100 2,425,747	2/17/42 8/17/47	Gleason, A. H. Lieber, E. and Thorner, M. E.
Aliphatic-aromatic ketones and formaldehyde.	2,384,935	9/18/45	Lieber, E.
Aliphatic ketone and an aromatic compound.	2,422,247	6/17/47	Lieber, E. and Cashman, A. F.
Aliphatic ethers and aromatic compounds	2,411,578	11/26/46	Lieber, E. and Thorner, M. E.
Alkylated and acetylated paraffin wax	2,114,812	4/19/38	Reiff, O. M. and Badertscher, D. E.
Alkylated hydroxyaromatic carboxylic acids or their metal salts.	2,386,206	10/ 9/45	Giammaria, J. J. and Reiff, O. M.
Alkylated resinified products of aromatic hydrocarbons and aldehydes.	2,412,589	12/17/46	Lieber, E.
Anthracene and amyl chloride	2,353,053	7/ 4/44	Lieber, E. L.
Aromatic compounds and acyl halides	2,346,926	4/18/44	Lieber, E.
Aromatic hydrocarbons and chlorinated paraffin wax.	2,174,246	9/26/39	Lieber, E. and Sadlon, M.M.
Aromatic substituted aliphatic halide and alkyl halide.	2,377,433	6/ 5/45	Lieber, E.
Benzene and paraffin wax	2,378,763	6/19/45	Frey, F. E.
Benzene or naphthalene acylated in two or more stages.	2,322,036	6/15/43	Lieber, E. and Rice, H. T.
Bromophenol or monochloro-naphthalene and paraffin wax.	2,049,058	7/28/36	Gleason, A. H.
Cashew-nutshell oil and phosphorus sulfide.	2,411,160	11/19/46	Hughes, E. C.
Chlorinated aliphatic hydrocarbon and carnauba, montan or similar wax.	2,081,519	5/25/37	Wade, M. L.
Chlorinated ester wax, aromatic hydrocarbon and formaldehyde.	2,147,546	2/14/39	Reiff, O. M.
Chlorinated paraffin wax and an aliphatic compound.	2,249,317	7/15/41	Lieber, E.
Chlorinated paraffin wax and butyl phthalate or phenyl benzoate.	2,332,824	10/26/43	Young, P. L.
Chlorinated paraffin wax and an ether.	2,128,109	8/23/38	Gaylor, P. J.

(Continued on next page)

TABLE 1-D (Continued)

Substance or Reacting Materials	U.S. Patent	Date	Inventor
Chlorinated paraffin wax and a hydrocarbon resin from spent clay	2,251,774	8/ 5/41	Agnew, M. S., Schindler, H. and Ayers, G. W., Jr.
Chlorinated paraffin wax and naphthenic acid	2,322,012	6/15/43	Frolich, P. K.
Chlorinated paraffin wax and a partially hydrogenated aromatic hydrocarbon	2,246,311	6/17/41	Lieber, E. and Sadlon, M.
Cracked pitch extract	2,200,534	5/14/40	Bray, U. B.
Cracked pitch and a chlorinated aliphatic hydrocarbon	2,081,518	5/25/37	Wade, M. L.
Cyclic aliphatic alcohols and aromatic hydrocarbons	2,383,606	8/28/45	Lieber, E. and Thorner, M. E.
Cyclic compound derivative and an aliphatic dihalo organic compound	2,270,062	1/13/42	Lieber, E.
Diphenyl amine and dechlorinated wax	2,288,392	6/30/42	Davis, G. H. B.
Fatty oils and aluminum chloride	2,267,111	12/23/41	Knowles, E. C.
Halogenated abietic acid and aromatic compounds	2,364,454	12/ 5/44	Lieber, E. and Rice, H. T.
Halogenated castor oil and an aldehyde, alcohol, isocyanate or isothiocyanate	2,150,156	3/14/39	Dietrich, M. A.
Hydrogenated tars from cracking processes	1,953,039	3/27/34	Bonnell, L. S.
Naphthalene, amyl chloride and ethylene dichloride	2,336,620	12/14/43	Lieber, E. and Cashman, A. F.
Naphthalene and chlorinated wax	2,113,179	4/ 5/38	Kay, W. B.
	2,135,044	11/ 1/38	Bartlett, J. H. and Gleason, A. H.
	2,172,382	9/12/39	Henricksen, A. and Lincoln, B. H.
	2,209,462	7/30/40	Lieber, E. and Sadlon, M. M.
	2,297,292	9/29/42	Davis, G. H. B. and Swoope, C. C.
	2,189,924	2/13/40	Pier, M., Christmann, F., Eisenhut, A. and Hirschberger, W.
Naphthalene, chlorinated wax and phosphorus sulfide	2,316,096	4/ 6/43	McLaren, F. H.
Naphthalene, chlorinated stearone and chlorinated ethane	2,379,229	6/26/45	Gleason, A. H.
Naphthalene and ethylene chloride	2,352,280	6/27/44	Mikeska, L. A.
Naphthalene, halogenated wax and an acyl halide	2,288,319	6/30/42	Mikeska, L. A. and Lieber, E.
Naphthalene and methyl oleate or oleic acid	2,106,247	1/25/38	Gleason, A. H.
Naphthalene, monochlorowax and trioxymethylene	2,052,003	8/25/36	Reiff, O. M.
	2,061,008	11/17/36	Reiff, O. M.
	2,062,676-7	12/ 1/36	Reiff, O. M.
Naphthalene and propylene oxide	2,381,457	8/ 7/45	Lieber, E. and Thorner M. E.
Nitrile and an alkyl halide	2,415,699	2/11/47	Lieber, E.
Olefins and sulfuric or phosphoric acid	2,281,941	5/ 5/42	Lieber, E.
Oleic acid, ethylene dichloride and an aromatic hydrocarbon	2,043,836	6/ 9/36	Moran, R. C.
Oleyl alcohol and thionyl chloride	2,147,315	2/14/39	Pier, M. and Christmann, F.
Oxidized waxy hydrocarbons	2,055,482	9/29/36	Davis, G. H. B.
Phenol, chlorinated wax and orthophosphitobenzoyl chloride	2,177,923	10/31/39	Berger, H. G., James, W. H. & Badertscher, D. E.
Phenol, chlorinated wax, salicylic acid and phosphorus trichloride	2,205,337	6/18/40	Berger, H. G., James, W. H. and Badertscher, D. E.
Phenol and chlorinated ester wax	2,147,545	2/14/39	Reiff, O. M.
Phenol and chlorowax	2,091,498	2/27/40	Reiff, O. M.
Phenol derivative and benzyl chloride	2,330,722	9/28/43	Lieber, E.
Phenol hepta-deryl ketone and ethylene dichloride	2,287,110	6/23/42	Lieber, E.
	2,341,454	2/ 8/44	Lieber, E.
Phenol and petroleum wax	2,191,499	2/27/40	Reiff, O. M.
Polybasic acids, unsaturated amines and saturated aromatic amines	2,412,708	12/17/46	Blair, C. M., Jr.
Polybasic unsaturated carboxylic acid and an unsaturated alcohol	2,375,516	5/ 8/45	Blair, C. M., Jr.
Polybasic unsaturated carboxylic acid, unsaturated alcohol and saturated alcohol	2,422,881	6/24/47	Blair, C. M., Jr.
Pyroligneous condensation products extracted with alcohol	2,204,967	6/18/40	Moser, F. H.
Rubber and aluminum chloride	2,142,219-20	1/ 3/39	Steffen, E. M.
Solvent extracts	2,080,088	5/11/37	Moser, F. H.
Stearic acid and triethylene-tetramine	2,291,396	7/28/42	Lieber, E.
Stearyl chloride and a coal tar material	2,033,546	3/10/36	Christensen, C. W. and Selby, W. M.
Sucrose and stearic acid	2,022,990	12/ 3/35	Van Peski, A. J.
Sulfur, selenium or tellurium derivatives described in U. S. patent 2,197,835	2,263,445	11/18/41	Reiff, O. M.
Sulfurized lard oil	2,343,608	3/ 7/44	Jule, J. S.
Sulfurized sperm oil	2,367,362	1/16/45	McCoy, F. C. and Towne, C. C.
Tall oil	2,270,319	1/20/42	Lieber, E.
Tar pitch	1,859,692	5/24/32	Black, J. C.
Wax-phenol carboxylic acid and sulfur chloride	2,359,331	10/ 3/44	Reiff, O. M.
Wax tailings	1,917,875	7/11/33	Davis, G. H. B.

TABLE 2

Physical Properties of Commercial Pour Point Depressants

	SANTOPOUR		PARAFLOW		Acryloid 150
	Regular	B	P.D.	46	
Flash Point, °F.	400	400	450	450	400
S.U.V. 210 °F.	60	75	140-160	110-130	3100
Carbon Residue			1.7	1.2	
Gravity, °API	29.5	28.5	26.5	27.0	27.0

TABLE 3

Agents Recommended for Treating Oils to Depress Pour point

Treating Agent	U.S. Patent	Date	Inventor
Adipyl chloride	2,330,064	9/21/43	Lieber, E.
Stearyl chloride	2,231,148	2/11/41	Bartlett, J. H.
Voltchination	2,088,869	8/ 3/37	Breth, F. W.
Ultraviolet light	2,138,868	12/ 6/38	Liberthson, L.

TABLE 4

Wax Modifiers Specifically Recommended for Use in Dewaxing Processes

Modifier	U.S. Patent	Date	Inventor
Aluminum stearate	2,155,845	4/25/39	Evans, L. P. and Grose, H. H.
	2,158,358	5/16/39	Evans, L. P.
	2,178,328	10/31/39	Story, L. G.
	2,132,355	10/ 4/38	Knowles, E. C.
	2,150,547	3/14/39	Hendrey, W. B. and Knowles, E. C.
Amorphous wax	1,881,643	10/11/32	Jones, L. D
	2,036,188	4/ 7/36	Anderson, J. A.
Asphaltic substances	1,857,404	5/10/32	Schott, J. E.
	2,031,108	2/18/36	Hopper, B.
	2,034,175	3/17/36	Chase, G. F. and Anderson, J. A.
	1,967,099	7/17/34	Osterstrom, R. C. and Wagner, C. R.
	1,901,240	3/14/33	Henriksen, A.
	1,998,648	4/23/35	Anderson, J. A.
	2,081,297	5/25/37	Garofalo, R. J. and Swift, C. E.
Butylamine	2,225,546	12/17/40	Burk, R. E. and Hughes, E. C.
Chlorinated and then dechlorinated paraffin wax	2,129,752	9/13/38	Whiteley, J. M.
Chromium soaps of fatty acids	2,181,638	11/28/39	Cook, L. W.
Cracked pressure tars	2,045,305	3/23/36	Manley, R. E., McCarty, B. Y. and Gross, H. H.
	2,141,257	12/27/38	Thiele, E. W. and Ginsberg, B.
	2,164,776	7/ 4/39	McCarty, B. Y.
Coal tar constituents	1,857,370	5/10/32	Funsten, S. R.
Cresol, nitrobenzene, etc.	2,107,770	2/ 8/38	Wade, M. L.
Fatty oils and aluminum chloride reaction products	2,267,093	12/23/41	Hall, F. W. and Meyer, W. N.
Heavy hydrocarbon distillates	1,963,175	6/19/34	Quinn, T. W.
	2,053,872	9/ 8/36	Montgomery, S. A.
Hydrogenated fatty glycerides	2,327,445	8/24/43	Nill, E. A.
Glycerides, polymerized	2,261,901	11/ 4/41	Frolich, P. K. and Wasson, J. I.
Glycerol tristearate	2,100,915	11/30/37	Pevere, E. F.
Hydrostearic acid esterified with stearic acid	2,100,916	11/30/37	Pevere, E. F. and Ludeman, C. C.
Lanolin or wool grease	2,099,190	11/16/37	Barnes, C. D. and Flaxman, M. T.
Lanolin or wool grease, oxidized	2,119,938	6/ 7/38	Barnes, C. D. and Flaxman, M. T.
Lead naphthenate	2,150,547	3/14/39	Hendrey, W. B. and Knowles, E. C.
Monohydroxystearic acid	2,196,374	4/ 9/40	Wasson, J. I. and Gleason, A. H.
Montan, carnauba or bees wax	2,107,772	2/ 8/38	Wade, M. L.
Montanic, carnaubic, melissic, cerotic or stearic acid	2,107,771	2/ 8/38	Wade, M. L.
Montan wax	2,132,355	10/ 4/38	Knowles, E. C.
	2,150,552	3/14/39	Knowles, E. C.
	2,158,370	5/16/39	Knowles, E. C.
	2,260,994	10/28/41	Knowles, E. C.
Montan wax and cellulose stearate	2,161,581	6/ 6/39	Knowles, E. C.
Oxidised wax	2,158,671	5/16/39	Carr, D. E. and Wade, M. L.
	2,119,940	6/ 7/38	Carr, D. E. and Wade, M. L.
"Plioform"	2,244,407	6/ 3/41	Smiloff, W.
Reaction product of alcohol and aniline or phenol	2,085,519	6/29/37	Verver, C. G.
Reaction product of rubber and tin or boron halide	2,147,573	2/14/39	Cook, L. W. and Towne C. C.
Pitch from sulfuric acid sludge	2,150,501	3/14/39	Halloran, R. A. and Lyman, A. L.
Triethanolamine soaps	2,059,837	11/ 3/36	Anderson, J. A.
Various pour point depressants	2,123,833	7/12/38	Knowles, E. C.
	2,134,336	10/25/38	Knowles, E. C.
	2,147,579	2/12/39	Knowles, E. C.
Wool grease	2,209,168	7/23/40	Meyer, W. W. N.

End of Part I

Part II of Mr. Kalichevsky's treatment of

LUBRICATING OIL ADDITIVES

will appear in an early issue of

PETROLEUM REFINER

Figure 1. Typical Refinery Installation of Steam Transmission Piping. (Courtesy Crane Company)

Transmission Piping for Refinery Steam System

PART II

TYLER G. HICKS, Hicks Associates, New York

AS NOTED IN the first section of this three-part series, steam systems in process plants are commonly found to be at all levels of efficiency from the most economic operation to very low efficiency with costly heat losses, excessive pressure drops, and wasteful condensate removal arrangements. Of course, more is involved in setting up efficient plant steam systems than the correct planning and sizing of piping, since many choices of heat utilization and equipment selection are necessary. The piping system proper, however, is the place where many otherwise satisfactory plans for steam generation, distribution and utilization fall far short of the optimum possible efficiency. In this section the author considers problems of expansion encountered in steam transmission lines. A later section will treat the economics of such systems.

ONCE suitable pipe sizes and steam conditions have been studied, expansion problems can be investigated. It will be recalled that a 16-inch nominal pressure loss line and a 10-inch maximum pressure loss line were found suitable. The various means for absorbing the thermal expansion of both these lines will now be examined.

Caring for Expansion

There are four common methods of absorbing thermal expansion:

(1) Use of expansion U bends.

(2) Use of double offset expansion U bends.

(3) Use of slip joints.

(4) Use of expansion bends composed of welding elbows.

The four schemes are shown in Figure 2. Each has certain inherent

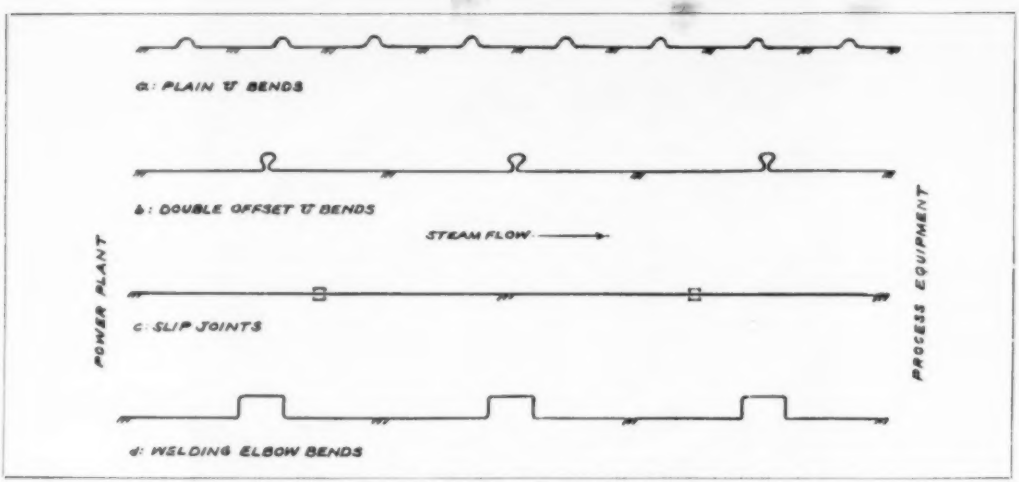


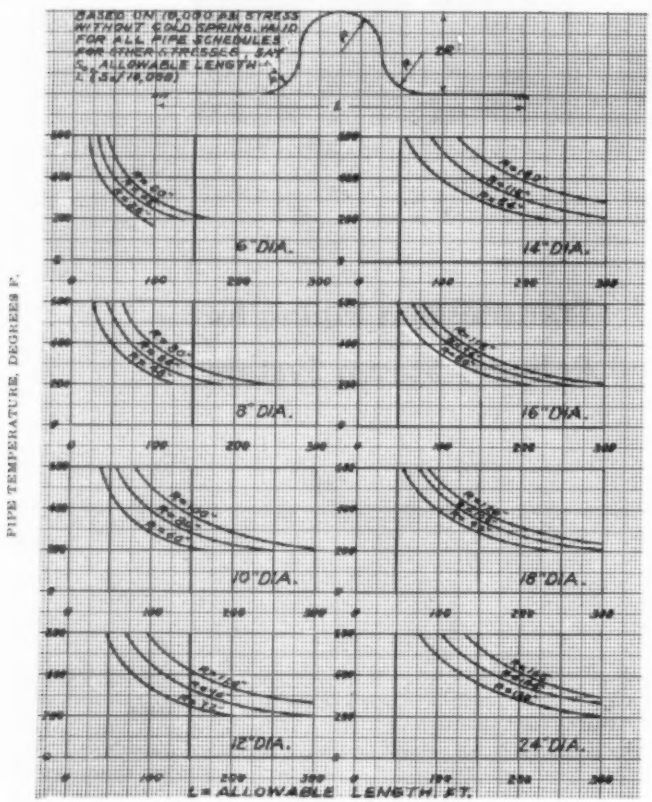
Figure 2. Piping Arrangement for 16-Inch Line

advantages. The best is that which will absorb the thermal expansion at minimum first, operating, and maintenance costs and has the longest life.

The expansion of each line can readily be computed on a form such as shown in Table 1. The appropriate temperatures, coefficients of expansion, and total expansions are tabulated for each pipe. A record of these computations should be kept for possible future reference. Leaky flanges and broken anchors are often blamed on the piping designer.

FIGURE 3

L = Allowable Distance Between Anchors for Expansion U Bends


BASED ON 10,000 P.S. STRESS WITHOUT COLD SPRING. VALID FOR ALL PIPE SCHEDULES FOR OTHER STRESSES, SAY S
L = ALLOWABLE LENGTH IN FT.
D = 2R
6" DIA.
8" DIA.
10" DIA.
12" DIA.
14" DIA.
16" DIA.
18" DIA.
24" DIA.
PIPE TEMPERATURE, DEGREES F.
L = ALLOWABLE LENGTH IN FT.

Method 1—Expansion U Bends: Expansion U bends have been and are still extensively used in long refinery lines. Since about 1920, when intensive American investigation of pipe bends began, many methods for solving U bends have been presented. To eliminate as many calculations as possible, a semi-graphical analysis of U bends used in refinery lines is presented here. The curves are based on usual analytical methods and are sufficiently accurate for ordinary design practice.

Using the allowable minimum radius of 80 inches in the 16-inch line U bends, allowable pipe length from Figure 3 is 97.0 feet for 365° F. operating temperature. Allowable lengths given in Figure 3 are based on an assumed bending stress of 10,000 psi., with cold springing neglected.

The ASA Code For Pressure Piping, B31.1, in paragraph 620g states that combined stresses due to bending and pressure shall not exceed three-fourths the sum of the S value at atmospheric temperature and the S value at nominal operating temperature. In equation form:

$$S_{bp} = 0.75\,(S_{amb} + S_h) \qquad (1)$$

For the 16-inch line operating at 365° F., using S values from Table 3, Part I, for ASTM A53, Grade A pipe,

$S_{bp} = 0.75\,(12{,}000 + 10{,}968) = 17{,}200$ psi.

The Piping Code also states that the longitudinal pressure stress is to be found by dividing the end force due to internal pressure by the cross-sectional area of pipe wall. Or.

$$P_L = \frac{p\,a}{a_m} \qquad (2)$$

For the 16-inch line which operates at a maximum pressure of 165 psig. and for which schedule 40 pipe was selected,

$$P_L = \frac{165\ (176.7)}{24.35} = 1197 \text{ psi., say } 1200 \text{ psi.}$$

Permissible bending stress at 365° F. is now found by taking the difference between S_{bp} and P_L, or

$$17{,}200 - 1200 = 16{,}000 \text{ psi.}$$

This is the permissible bending stress in 97 feet of 16-inch pipe. However, the length of 97 feet is based on an allowable stress of only 10,000 psi., Figure 3. Therefore, the length for a permissible bending stress of 16,000 psi. is found by multiplying 97 feet by the ratio of the stresses, or permissible pipe length = 97 (16,000/10,000) = 155 feet.

To reduce the number of bends necessary, the pipe can be cold sprung into the desired position. To take advantage of the maximum cold spring allowable under the Piping Code, 50 percent or more of the computed expansion is cut from the pipe. When this is done the allowable pipe length as found from stress calculations can be multiplied by 1.5. Hence, actual permissible pipe length = 155 feet (1.5) = 232 feet.

Now, the number of U bends required to care for expansion is $\frac{1700 \text{ feet}}{232 \text{ feet}}$ or 7.34. Since only a whole number of bends can be used, eight bends, $\frac{1700}{8}$ or 212 feet over-all are needed. Actual bending stress is therefore $\frac{S_a}{10{,}000} = \frac{212/1.5}{97} = 14{,}600$ psi., which compares favorably with the permissible value of 16,000 psi. Values in the equation are from this and the two preceding paragraphs and are used to form a simple proportion between actual stress and that used in Figure 3.

Anchor reactions or forces for the 16-inch line can be obtained from Figure 4. At 365° F., a 16-inch schedule-40 pipe sets up a force of 8200 pounds. This force, however, is based on an allowable stress of 10,000 psi. Converting to the actual stress existing, the reaction is 8200 (14,600/10,000) = 12,000 pounds. Adjustment for cold spring is not necessary because it has but negligible effect on anchor forces.

Good design would locate anchors as shown in Figure 2a. Anchors between bends are actually unnecessary during normal operation because forces between any two bends are equal and opposite. However, uneven warming of the line with resultant unbalance of bend forces makes the use of anchors between bends desirable. They provide for more accurate control of the pipe during expansion and contraction without materially decreasing flexibility. In all cases anchors must be used at each end of the line to absorb the reactions.

The solution for the 10-inch maximum pressure loss line will not be detailed because it is made exactly as for the 16-inch line. Using 100-inch radius bends, eight are required. Each has an over-all height of about 17 feet and a length of about 212 feet. Bending stress is 12,500 psi. Anchor reactions are low, being about 2500 pounds at each.

Method 2—Double Offset Expansion U Bends: The solution for double offset U bends is the same as for the plain

FIGURE 4
Anchor Reactions for Schedule 40 Expansion U Bends

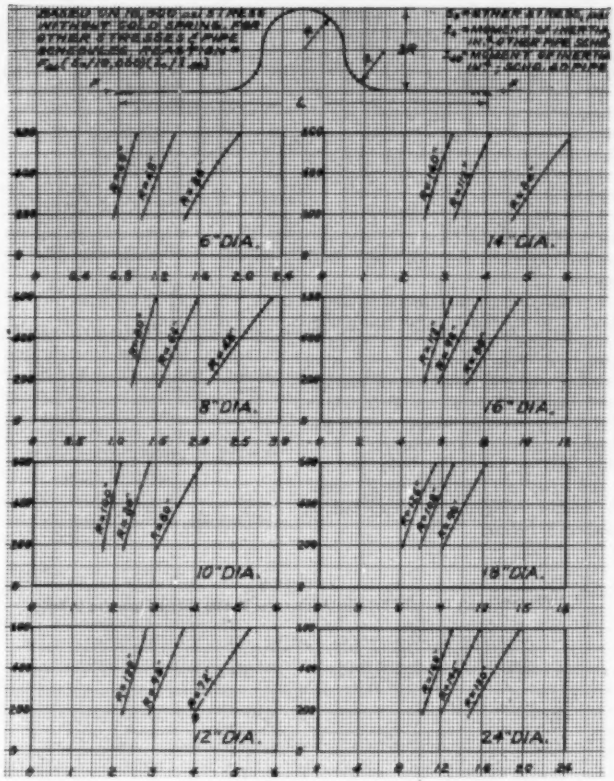


TABLE 1
Thermal Expansion of Steam Transmission Lines

	Nominal pressure line A53—Grade A Seamless Carbon Steel	Max. pressure line A53—Grade A Seamless Carbon Steel
1. Type of line		
2. Pipe material		
3. Nominal size of pipe, inches	16	10
4. Operating temperature, F.	365	455
5. Linear expansion coefficient, inches/100 feet at operating temperature	3.16	4.15
6. Linear expansion coefficient, inches/100 feet at installation temperature, assumed as 40° F.	0.43	0.43
7. Difference, inches	2.73	3.72
8. Length of transmission line, feet	1,700	1,700
9. Linear expansion, inches = $\frac{\text{(line 8) (line 9)}}{100}$	46.40	63.20

U bends except that Figures 5 and 6 are used. Figure 5 gives permissible bend lengths for stresses of 10,000 psi. Figure 6 gives corresponding reactions.

For the 16-inch nominal pressure loss line using double offset bends with 80-inch radii, length of each bend is 567 feet. Three bends are required whereas eight U bends were needed. Difference in number of bends shows that double offset U bends have a greater ability to absorb pipeline expansion.

Each bend will be about 23 feet high and actual stress in bend is 15,400 psi. Anchor reactions are low, only 6800 pounds.

For the 10-inch maximum pressure loss line using double offset bends with 70-inch radii, length of each bend is 340 feet. Five bends are required whereas eight U bends were needed. Each bend will be about 20 feet high and actual stress in bend is 13,000 psi. Anchor reactions are extremely low, only 2150 pounds. For both methods 1 and 2 support friction must be added to anchor reactions as described in method 3, below.

SYMBOLS AND ABBREVIATIONS

a = Cross-sectional area of pipe, square inches.
a_m = Cross-sectional area of pipe metal, square inches.
F = Degrees Fahrenheit.
L = Welding elbow bend length, feet.
p = Steam pressure, pounds per square inch gauge.
psi. = Pounds per square inch.
psig. = Gauge pressure, pounds per square inch.
P_L = Longitudinal pressure stress, pounds per square inch.
S_a = Actual bending stress in pipe, pounds per square inch.
S_b = Allowable bending and pressure stress, pounds per square inch.
S_a = Allowable stress at operating temperature, pounds per square inch (from ASA Piping Code).
S_{am} = Allowable stress at 150° F., pounds per square inch, taken as "atmospheric" temperature for stress calculations.
W = Welding elbow bend width, feet.

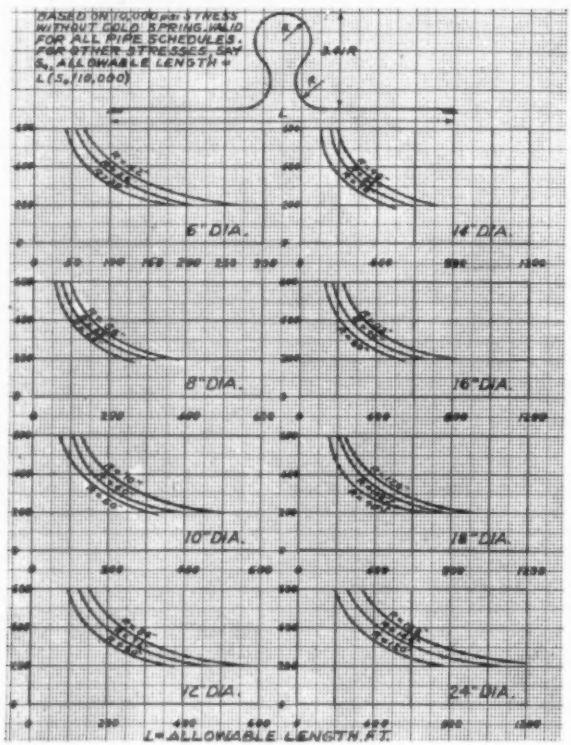
Method 3—Slip Joints: From Table 1 it is seen that the 16-inch line will expand about 47 inches and the 10-inch line about 63 inches. Double ended slip joints which can absorb up to 24 inches of expansion are available. Hence number of joints needed, N, is

16-inch line, $N = \frac{47}{24}$ or 2;

10-inch line, $N = \frac{63}{24}$ or 3

FIGURE 5

L = Allowable Distance Between Anchors for Double Offset Expansion U Bends


BASED ON 10,000 psi STRESS WITHOUT COLD SPRING. VALID FOR ALL PIPE SCHEDULES. FOR OTHER STRESSES, SAY S_a, ALLOWABLE LENGTH = L (Sa/10,000)
6" DIA.
8" DIA.
10" DIA.
12" DIA.
14" DIA.
16" DIA.
18" DIA.
24" DIA.
L = ALLOWABLE LENGTH, FT.

PIPE TEMPERATURE, DEGREES F.

The two joints for the 16-inch line would be installed between anchors as shown in Figure 2c. Joints in both lines are anchored to the ground or supporting structure.

Between joints the pipe must be adequately supported and free to move. Roller supports which guide and permit longitudinal movement are often used for this service.

Required anchor size and strength are functions of piping size, steam pressure, slip joint construction, and type of supports used. During expansion of the pipe, friction at supports and in the joint packing sets up a force which must be absorbed by the anchor. In addition, steam pressure in the joint tends to force it apart. The value of these forces can readily be computed and from the results a satisfactory anchor designed.

Support friction varies somewhat, but is usually assumed to be about 100 pounds per support. At least six supports per 100 feet are needed for the 16-inch line and seven for the 10-inch line.

Packing gland friction varies with different manufacturers, type of joint, and packing used. Gland friction in one type of slip joint frequently used in refinery work is about 2200 pounds per inch of pipe diameter. Assuming use of these joints in both lines, anchor forces are as follows:

16-inch nominal pressure loss line:

Support friction $= \frac{1700\ (6)}{100}$ (100 lb.) = ... 10,200 lbs.

Gland friction = $2200 \frac{\text{lb.}}{\text{in. dia.}}$ (16 in.) = ... 35,200 lbs.

Pressure force = 165 psig. steam pressure (176.7 sq. in. pipe area) = 29,200 lbs.

Total force to be absorbed anchor = ... 74,600 lbs.

10-inch maximum pressure loss line:

Support friction $= \frac{1700\ (7)}{100}$

(100 lb.) = ... 11,900 lbs.

Gland friction =
2200 $\frac{\text{lb.}}{\text{in. dia.}}$ (10 in.) = ... 22,000 lbs.

Pressure force =
425 psig. steam pressure
(78.9 sq. in. pipe area) = 33,500 lbs.

Total force to be absorbed
by anchor = ... 66,500 lbs.

Comparison of these results shows that the anchors for the 10-inch maximum pressure loss line will be smaller than for the 16-inch line. However, the 16-inch line requires only three anchors whereas the 10-inch line needs four anchors. Total cost of anchors for both lines will be approximately the same.

The principal advantages of slip joints become apparent when the piping layout is studied. Only a minimum of pipe is needed because it runs in a straight line between point of supply and use. Amount of insulation is likewise a minimum.

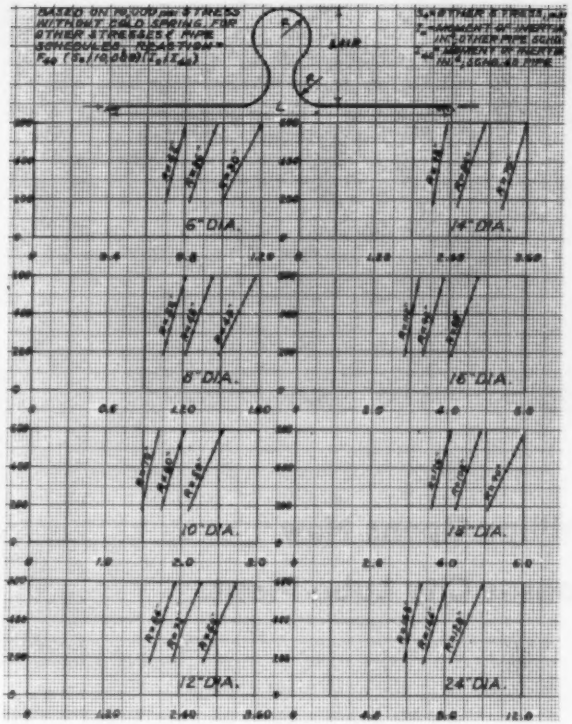
Method 4—Expansion Bends Using Welding Elbows: Detailed solution of these bends will not be presented because many graphical and semi-graphical methods are available. These will be found in piping catalogs and several handbooks.

The most economical size of bend, however, deserves some consideration. When bend width, W, divided by distance between anchor points, L, is ½, the most economical bend is being used. In a bend of these dimensions the longitudinal stresses at top and bottom are equal. Use of such bends, while desirable, is not always feasible because existing piping or structures interfere.

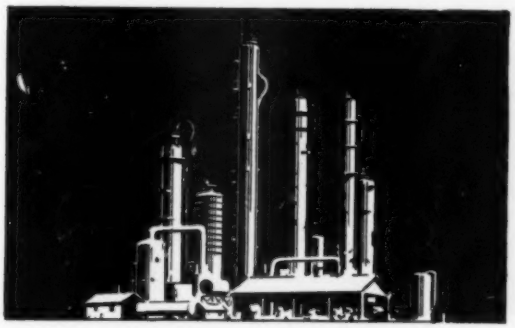
When bend dimensions other than the most economical must be used, it will be found that maximum longitudinal stress occurs at top when $\frac{W}{L} < 0.5$. When $\frac{W}{L} > 0.5$, maximum stress occurs at bottom of the loop. Regardless of bend type, whether plain U, double offset U, or welded, actual stress in pipe must not exceed 40 percent of specified tensile strength of pipe material.

The economic aspects of the various piping arrangements will be discussed in Part III of this article.

FIGURE 6
Anchor Reactions for Schedule 40 Double Offset Expansion U Bends



F_{ar}=ANCHOR REACTIONS, THOUSANDS OF POUNDS.



Phillips Opens New Kansas City Lube Plant

Top of page, left—Worker couples hose between manifold (on the right) and blending equipment in the lube plant of Phillips Oil Company, Kansas City, Kan.

Above—A closeup view of fractionating towers at the Phillips plant.

A NEW lube oil manufacturing plant and a blending and packaging plant, which constitutes a completely integrated unit for the Phillips Petroleum Company line of aviation, automotive, and industrial lubricating oils, was formally opened by a subsidiary, Phillips Oil Company, in Kansas City, Kan., May 6 and 7.

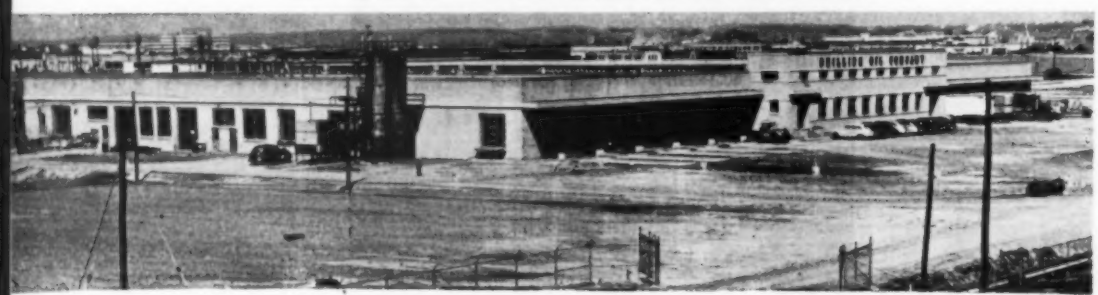
The new units for processing the base oils, a mixture of selected Oklahoma topped crudes, includes a two-stage vacuum still, two-stage propane fractionation unit, phenol extraction unit, propane dewaxing unit, and a clay finishing unit. The plant has a design capacity of 1500 barrels per day of finished lube oils.

The new blending and packaging plant is housed in a single-story brick and steel building. Most of the operations are automatic—the latest methods in blending and packaging of various types and grades of motor oil. The plant can blend and package 330 gallons of oil per minute.

The south third of the building contains facilities for unloading and storage of empty cans and for the unloading, washing, repairing, painting and inspection of empty-used drums. Storage space is also provided for new drums. The middle section contains equipment for blending, filling, and packaging. Packaged oil is moved from the center section of the building to the north end for storage and shipping. Continuous roller conveyor systems are used throughout.

No tankage is provided for finished blended oils, which are blended in automatic machines and packaged as required. Each base stock and additive has separate pumps and lines from the storage tank to the blending machine, which allows for maximum flexibility in the switching of base oils and additives to

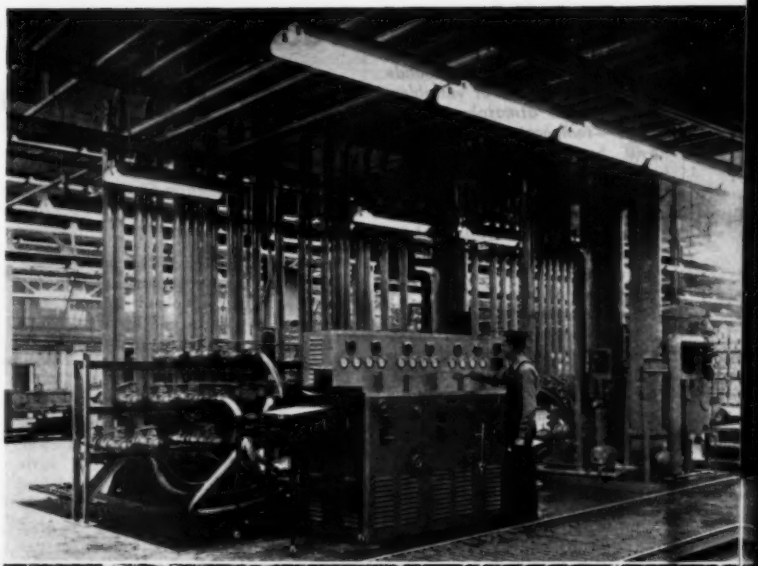
Below shows general view of Phillips' new lube plant, opened last month at Kansas City, Kan.

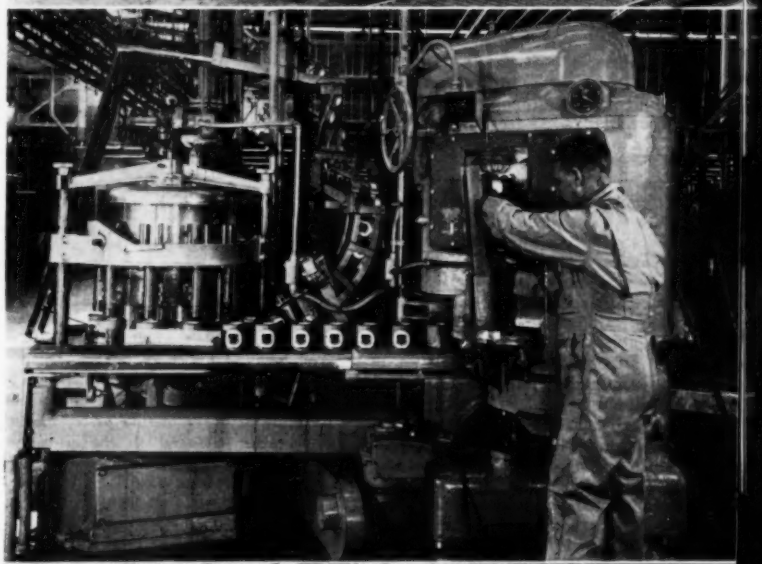


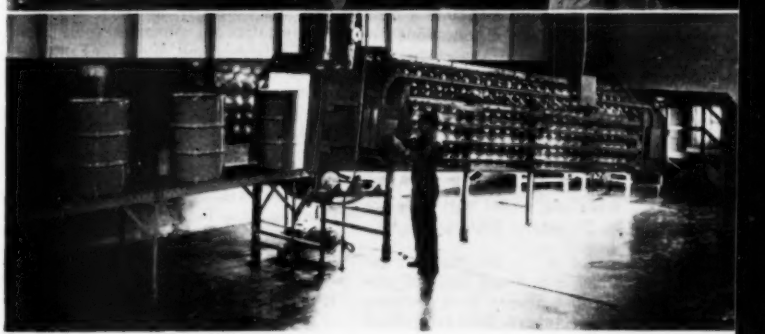
Top photo at right: Blending and homogenizing of oil are automatically controlled at Phillips' new Kansas City, Kan., plant.

Center photo: The one-quart canning machine in the new lube plant fills 200 quart cans of motor oil per minute.

Bottom photo: After oil drums are painted in the new Phillips plant, they pass through an electrically heated drying oven. Then they pass along a conveyor system to be filled.







provide for the type of finished blended oils needed.

The plant contains four automatic blending units, three of which have a capacity of 90 gallons per minute and the fourth, 60 gpm. Each unit is capable of handling three base oils and three additives simultaneously. In addition to blending the components, the equipment deaerates and dehydrates the finished lube oils. Steam heaters for the oil is provided ahead of the blending units to assure the proper blending temperature, and a water cooler is provided for the blended oil leaving the equipment. Temperature of the cooling water is controlled by a refrigeration unit.

Each base stock and additive is provided with separate lines and pumps from the storage tanks to the blending unit. Base oil transfer lines from storage to the compounding plant are enclosed in a steam-heated, concrete-pipe trench for ease in winter operation. Outside lines at the compounding plant are steam traced and insulated.

To prevent moisture contamination of products, the breathers of the base stock storage tanks are connected to a common battery of bauxite driers. The separate pumps for stocks and additives are reversible and can pump out lines to prevent contamination. Also, connections at the automatic blending units are made with flexible metal hose which minimizes contamination.

Oil from the blending units passes through the water cooler to the drum fillers, canning machines, or to tank cars. Drums are filled, closed, and sealed, then on wooden pallets are moved on the conveyors to the north end of the building, where further handling for storage or shipping is done by fork trucks.

Three canning machines are used in the plant, one with a capacity of 250 quart cans per minute, one 150 one-quart cans per minute, and a third 35 five-quart cans per minute. Each canning machine is equipped with boxing and sealing equipment.

The small quantities of specialty oils, which cannot be blended economically through one of the large automatic blending units, are blended in three small batch blending tanks, one of 810 gallons capacity and two of 324 gallons capacity. Adjacent to these tanks are ten melt-down tanks for heating and removing from drums the various additives used.

Factors Affecting Octane Number Requirement

HAROLD J. GIBSON,
Research Coordinator, Ethyl Corporation, New York

***THE OCTANE** number requirement of a given engine depends on a large number of variables, among them atmospheric variables—temperature, pressure, and humidity—combustion chamber deposits, ignition timing, hot spot temperature, and cooling jacket temperature. Herein is discussed results of investigations aimed at determining the effect of these and other variables responsible for the octane number requirements of engines. A study of the effects of various types of fuels and lubricants offers interesting possibilities for reduction of the octane requirement due to deposition. Engine adjustments are responsible for variations in requirement from engine to engine.*

Tests with a standard transmission and a torque converter drive indicate that the converter eliminates loading at low speeds, reducing the maximum requirement of both engines slightly; however, the maximum requirements for the converter were 3-5 units higher than would have been predicted from the curves for the standard transmission.

IT IS approximately 20 years since the octane number scale for evaluating fuels was suggested and approximately 16 years since what is now the ASTM Motor Method was standardized. During this period very substantial progress has been made in the evaluation of fuels in laboratory engines and in cars on the road. Likewise, great progress has been made in developing engines to use the much improved fuels that have been made available. There seems to be, however, a marked sense of frustration on the part of many engineers when the subject of determination of octane number requirement of engines is mentioned. A multitude of questions are raised, of which the two most common are:

(1) Why does the requirement of a given engine vary so much from observation to observation?

(2) Why do engines of the same make and model vary as much as 20 octane units in requirements?

No pretense is made here of presenting a final answer to these questions or the others that are raised. Instead, it is hoped that it will contribute to an understanding of some of the factors involved in antiknock requirement work, and serve to stimulate discussion of this important problem.

Test Tools

What is the octane number requirement of a given engine? The answer depends on a large number of variables. First, it is necessary to define what is meant by requirement. Unless otherwise stated, the octane number requirement of a given passenger car engine is, for the purposes here, defined as the octane number of the blend of primary reference fuels which produces no more than borderline knock during level road, full throttle acceleration from low vehicle speed (usually 10 miles per hour), to 60 miles per hour or 3000 engine rpm. It is realized that this may not always be the worst knocking condition for an engine, but much of the data used herein were obtained by this procedure.

For years it was customary to state requirements in terms of the Motor octane number of the blend of secondary reference fuels which gave the desired level of knock in the engine in service. When n-heptane and iso-octane (2,2,4-trimethyl pentane) became available at a reasonable price, most laboratories changed to the use of these primary reference fuels for both road and laboratory work. Lately, it has been proposed that "sensitive" reference materials be used to measure the requirements of engines, since such materials would presumably be more representative of commercial fuels than are heptane-octane blends. Table 1 shows the stated requirements of a given vehicle engine when evaluated with the three types of reference fuels: a) blends of n-heptane and iso-octane; b) blends of secondary reference fuels C and F; and c) blends of n-heptane and diisobutylene. Just to confuse the issue further, the results are expressed in terms of both Motor and Research octane number calibrations of all fuels.

It is apparent that the octane number requirement which is recorded is dependent upon the fuels used and that it is necessary to agree on a system of fuels. Unless otherwise indicated, all discussion in this paper will be based

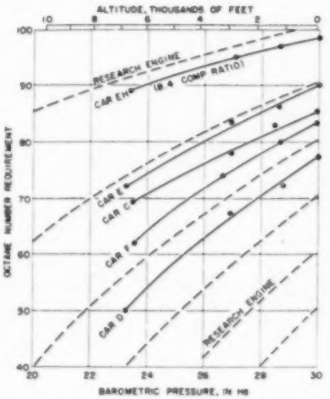


FIGURE 1. Effect of Change in Barometric Pressure on Octane Number Requirement of Several Cars. (Change in octane number requirement due to change in altitude from 50 feet below to 6600 feet above sea level and comparison with data obtained on Research Method engine in altitude chamber at Bureau of Standards.)

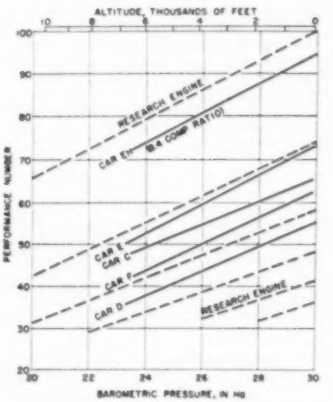


FIGURE 2. Effect of Change in Barometric Pressure on Performance Number Requirement of Several Cars. (Data of Figure 1 converted to performance numbers using equation $PN = \frac{2800}{128\text{-}ON}$.)

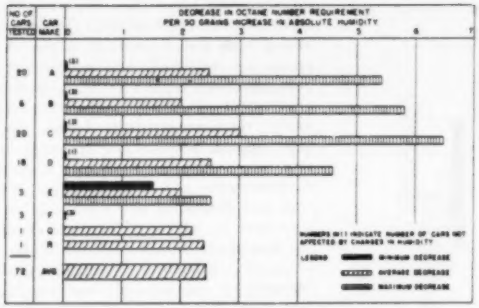


FIGURE 3. Effect of Change in Absolute Humidity on Octane Number Requirement. (Atmospheric temperature constant but no allowance made for change in dry barometric pressure.)

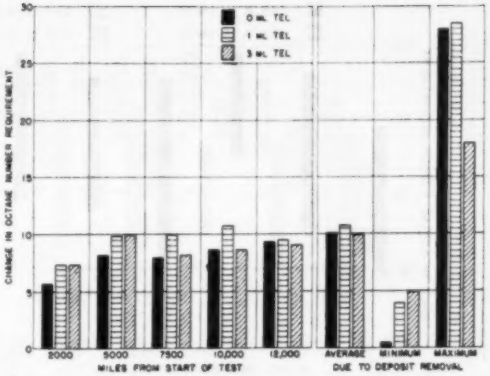


FIGURE 6. Effect of Fuel TEL-Content and Test Mileage on Change in Octane Number Requirement. (Fleet of 66 1946 Ford, Chevrolet, and Plymouth cars operated in normal city and country service. Fuel catalytically cracked naphtha. Oil 100% Pennsylvania regular. Oil changed at 5000-mile intervals.)

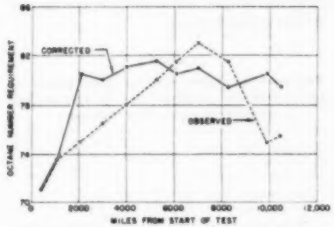


FIGURE 4. Change in Requirement with Mileage. (Typical data as observed and after correction for absolute humidity.)

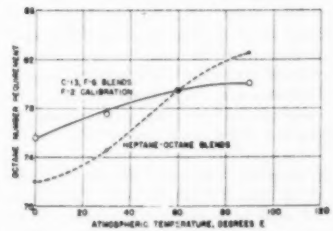


FIGURE 5. Effect of Change in Atmospheric Temperature on Octane Number Requirement. (Change in requirement of temperature-sensitive car with change in atmospheric temperature. Two sets of reference fuels. Humidity and dry barometric pressure constant.)

on requirement in terms of heptane-octane, which automatically eliminates the calibration problem.

Effect of Atmospheric Variables

Before time is spent on discussion of some of the fuel, engine, and lubricant variables which can affect the requirement of any given engine to a major degree, it would be well to examine the effect of the atmosphere in which the engine normally operates on its tendency to knock on a given set of reference fuels.

Data which have been accumulated over a period of years indicate that barometric pressure, temperature, and humidity all may be important factors in the knocking tendency of any given engine. The effect of barometric pressure on vehicle engine requirement has been demonstrated by two investigators,[1,2] and by the Bureau of Standards in altitude chamber work with the CFR engine.[3]

As confirmation of the aforementioned data, five passenger cars with stabilized deposits were run in the vicinity of San Bernardino, California, at altitudes varying from 50 feet below to 6600 feet above sea level. Absolute humidity varied only about 20 grains, average, for these tests and temperature change was less than 30° F. The cars were driven from low to high altitude and return and requirement determined at four different locations on the up and down trips.

The results are shown in Figure 1, superimposed on the Research Method background developed by the Bureau of Standards. It will be observed that over the range of barometric pressure covered there is good agreement with the Research Method curves, and it seems likely that extrapolation to 10,000 feet along the Research curves is quite safe. This is confirmed by examination of Figure 2 which shows the same data, converted to a performance number (PN) basis using the formula

$$PN = \frac{2800}{128\text{-}ON}$$

These observations indicate that for all practical purposes, the requirements of all engines are equally affected by variations in barometric pressure. (The industry badly needs a linear scale of antiknock value which is also continuous through 100 octane number. PN was used in this instance although it was realized that it may not apply too well to naturally aspirated engines.)

The effect of absolute humidity on octane number requirement was explored on the chassis dynamometer by adding steam to the air to change humidity over a range from 10 to 130 grains of water vapor per pound of dry air. This was sufficient to cover the range in atmospheric humidity normally encountered. Temperature was held constant and dry barometric pressure allowed to vary as humidity was changed. Results shown in Figure 3 indicate a wide variation among cars of the same, and different, makes under otherwise constant conditions. Average effect for the 72 cars tested was 2.5 octane units decrease for each 50 grains increase in moisture content of the air. Since 50 grains moisture is equivalent to 0.3 inch mercury, it has been suggested that about 0.9 unit of the 2.5 should be charged to change in dry barometric pressure. (See Figure 1.) This appears to be an unnecessary refinement at this stage, however.

The range among cars was from

TABLE 1

Octane number requirement of one car in terms of three reference fuel combinations and two calibrations

Reference Fuel Calibration	C, F		HEPTANE-OCTANE		HEPTANE DIISOBUTYLENE	
	Motor	Research	Motor	Research	Motor	Research
Octane Number	80	82.4	85	85	77.5	87.0

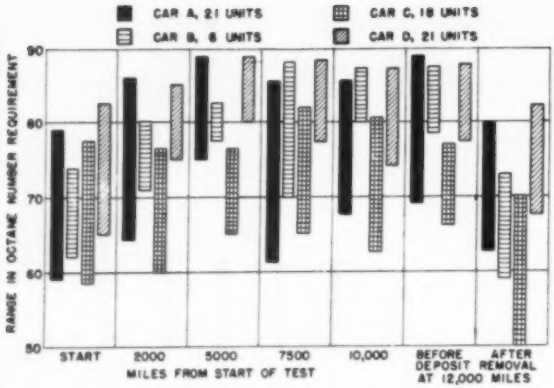


FIGURE 7. Range in Octane Number Requirement. Vehicles Same as Those Described in Figure 6.

zero to 0.5 units for the 50-grain change in water vapor. This variation eliminates the possibility of applying a blanket correction factor for humidity effect to the results obtained on any one car, but it seems that such correction can be applied to the results from a group of cars. It has also been observed that the effect of humidity is frequently greater with clean engines than when deposits have accumulated. The reason for the wide variation in effect are obscure, but absolute humidity is undoubtedly an important factor in the variation in requirement from observation to observation in the same car. This is demonstrated by Figure 4 which shows a plot of data from a road test run over a long period of time and the same data replotted with a correction applied for humidity effect. The correction factor used was developed for this particular car. It will be observed that most of the large variations in requirement were eliminated by the correction.

A number of the cars shown in Figure 3 were tested at three different atmospheric temperatures and constant humidity, hence the data obtained also show the effect of atmospheric temperature on requirement. Cars of make F were the only ones found to be significantly sensitive to temperature change, and curiously, were not affected by change in humidity. Figure 5 shows the effect of temperature on change in requirement of one of these cars. Requirement in terms of heptane-octane change,l about one unit for each 10° change in temperature. The change was only about half that great when secondary reference fuels were used. The reasons for this difference in performance are not definitely known, but it is suspected that differential distribution of the C and F fuels may have been responsible.

Effect of Combustion Chamber Deposits

Ethyl Corporation, in common with a number of other investigators, has accumulated data to show the effect of combustion chamber deposition on change in octane number requirement. These data are all based on a "before and after deposit removal" technique which minimizes the effects of all variables other than deposits. Octane number requirement is determined with the deposits in place, deposits are removed, and requirement determinations repeated with no engine adjustments. If road observations are made, requirement tests before and after deposit removal are repeated on two consecutive days. If the chassis dynamometer, and controlled temperature and humidity are used, one observation is sufficient. Table 2 shows the maximum, minimum, and average effect of combustion chamber deposit removal on requirement. One hundred and sixty-two tests, with a total of just over two million test miles, are represented in these figures, as are a wide variety of types of fuels, lead concentrations, lubricants, engines, and driving conditions.

TABLE 2

Decrease in octane number requirement of passenger car engines due to removal of combustion chamber deposits

Average of 162 tests	9.4 units
Maximum	28.5 units
Minimum	0 units

Included in the above data was a fleet test to study the effect of tetraethyllead concentration of the fuel on change in requirement due to deposits. While many data had been accumulated to show the effect of TEL, they were not sufficient to demonstrate statistically whether TEL was an important factor in requirement change. Arrangements were made, therefore, to use a portion of a public utility fleet for a study of the effects of lead concentration. Sixty-six 1946 Ford, Chevrolet, and Plymouth cars were used. All had been run for less than 15,000 miles at the start of the test. Each engine was thoroughly checked and put in good mechanical condition. In one make of engine it was necessary to remove the distributors, hence all were carefully adjusted to ±1° of the factory curves. Distributors in the other engines were not adjusted except

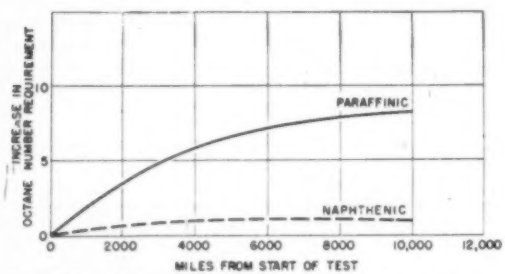


FIGURE 8. Effect of Lubricating Oil Type on Change in Requirement with Mileage. (Car F in carefully-controlled, driver operation. Fuel for both tests—typical blend + TEL.)

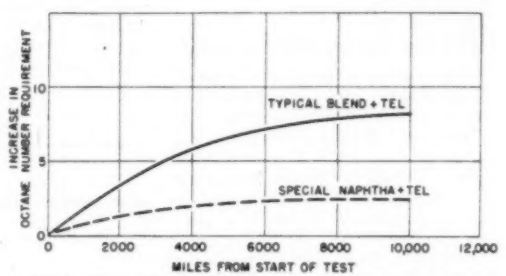


FIGURE 9. Effect of Base Fuel Type on Change in Requirement with Mileage. (Car F in carefully-controlled, driver operation. Oil 100% paraffinic.)

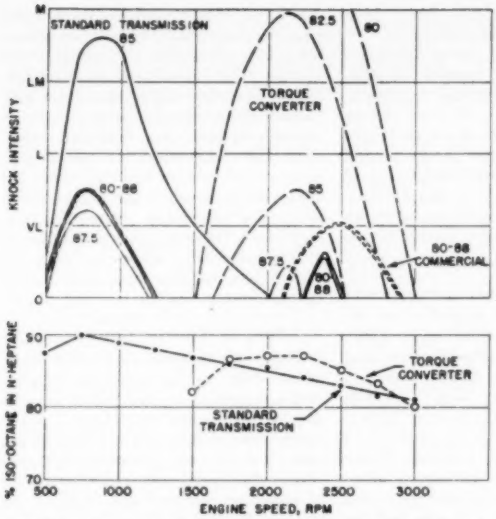


FIGURE 10. Octane Number Requirement and Knocking Tendency with Torque Converter and Standard Transmissions. (80-88 indicates motor and Research octane number of commercial gasoline. All other numbers indicate octane number of reference fuels. Engine E. All tests made using CRC E-1 procedure. Accelerations started at 500 rpm.)

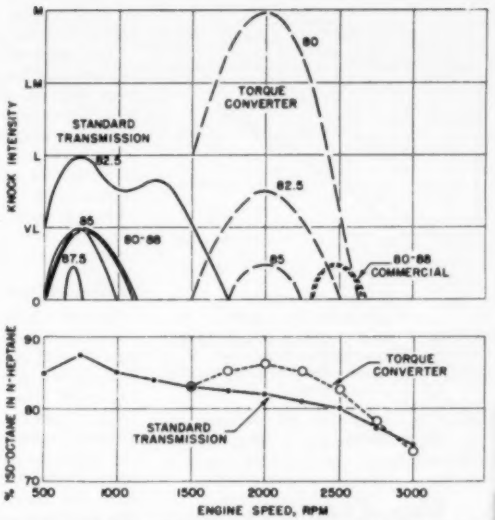


FIGURE 11. Octane Number Requirement and Knocking Tendency with Torque Converter and Standard Transmissions. (80-88 indicates motor and Research octane number of commercial gasoline. All other numbers indicate octane number of reference fuels. Engine EE. All tests made using CRC E-1 procedure. Accelerations started at 500 rpm.)

to give the proper basic timing. Combustion chambers were cleaned, requirements were obtained, and the cars returned to the operator's daily service in which they were assigned to a pool. Driving was mixed city and country, not unlike much average driving. Three groups of 22 cars, each divided as equally as possible among the three makes, were supplied with the same base gasoline, one group using it clear, another with 1.0 ml. TEL, and the third group with 3.0 ml. TEL per gallon. A fuel of high antiknock value without TEL was necessary to prevent knocking in the group of cars using clear fuel. Commercial catalytically cracked naphthas were used throughout the tests. These fuels can be considered as representative of possible future bases for very high quality premium gasoline. Average inspection data are shown in Table 3.

TABLE 3

Average inspection data—gasoline used in fleet test

Gravity °API	60.1
Reid Vapor Pressure, psi	10.2
Distillation:	
10 percent	119
50 percent	211
90 percent	331
Sulfur Percent	0.035
ASTM Gum	2.3
Oxidation Stability, Min.	920
Octane Number:	
ASTM-Motor-Clear	79
3.0 ml TEL	87
Research-Clear	89
3.0 ml TEL	97
Hydrocarbon Type:	
Paraffins	17
Olefins	23
Aromatics	43
Naphthenes	17

They were also clean fuels as indicated by a CRF FL-2 piston skirt rating of 9.

The lubricating oil was a widely distributed, regular grade, 100 percent Pennsylvania oil, of SAE 10 viscosity. Oil change period was 5000 test miles.

Requirement observations were made periodically as mileage was accumulated and before and after deposit removal at 12,000 test miles. The test was ended at this mileage since it was apparent that little was to be gained by further mileage accumulation. Requirement increase had substantially leveled off at 10,000 test miles. All data at 10,000 and 12,000 miles were obtained with the cars on the chassis dynamometer with humidity and temperature constant for all observations. In general, no adjustments other than basic ignition timing were made to the vehicles, since it was the purpose to show change in requirement from all causes during the test, and the effect of deposits at the end of test. The effects of TEL concentration, test mileage, and deposit removal on requirement are shown in Figure 6. Note that the values shown are average for a total of 22 cars of three makes at each lead concentration. It will be observed that the major part of the change due to mileage accumulation occurred in the first 2000 miles of operation and that the changes due to all causes during the test were slightly less than the change due to deposit removal at the end of the test. There was no difference in the effect of deposits from clear and leaded gasoline. The average results are in good agreement with respect to the effect of TEL and average level of increase with data accumulated from all other sources, indicating that the gasoline-oil combination was about average in effect on requirement. The extreme decrease of 28 due to deposit removal, occurring on both clear and leaded gasolines, resulted from a combination of change in engine speed for maximum knock and deposit effects.

Reference was made earlier to the wide variation in requirement from car to car of the same make. The fleet test just described provided excellent data in this respect. Figure 7 shows range in requirement obtained at each observational period. Note that there was about 20 octane units spread among cars of the same make at the start of the test when all were free of deposits and in good mechanical condition. Approximately the same spread prevailed throughout the test and when all were again clean and tested at substantially constant temperature and humidity. It should be pointed out that probably the only reason Car B shows so little spread is that only six units were tested. The question which immediately arises is why does this variation exist and what can be done about it?

A series of tests has been instituted to study the engines of high and low requirement of each of the makes in an

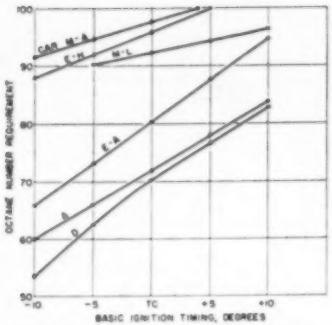


FIGURE 12. Effect of Change in Basic Ignition Timing on Octane Number Requirement. (Each curve represents data for a different model of engine.)

effort to determine the reasons for the large difference in requirement. The results of the study of one pair of the engines are reported below.

Effect of Lubricating Oils

The effect of lubricating oil type on change in requirement due to deposits has been recognized for many years. Merrill, Moore and Bray[4] pointed out in 1935 the marked effect of naphthenic oil in holding down increase in requirement. This effect was evaluated recently in a single car known to have a high degree of reproducibility from run to run with the same fuel, lubricant, and driving conditions. Figure 8 shows a comparison of requirement data obtained with a paraffinic oil of high viscosity index and with a naphthenic oil of low VI, both with the same base fuel containing TEL and in the same car operated by test driver under a carefully controlled driving cycle. It is clear that the naphthenic oil was far superior to the paraffinic in this respect. Statistically sound data would be required to determine the exact effect of lubricating oil type on requirement, and this should be a fertile field for investigation.

The data available are not adequate to show whether the popular oil additives used in the normal concentrations have significant effect on change in requirement due to deposits. If oils of high additive content are to be used in the future, attention should be paid to this factor, since it is entirely possible that high concentration of additives in the oil may affect octane number requirement.

Effect of Base Fuel Composition

In the same car used for the oil comparison described above, a single pair of tests on the effect of base fuel composition gave the results shown in Figure 9. The fuels were both full boiling range stocks, one a typical blend of several refinery stocks, and the other a special naphtha. While there is no definite indication as to why the special naphtha produced this desirable result, the data indicate that it may be possible to make gasolines which cause relatively little increase in requirement as deposits accumulate. As in the case of the lubricating oil comparison, statistically sound data would be required to establish the significance of the fuel effect. Research has just begun on the factors that might be responsible for the differences shown, but it presently appears that there may be striking difference in the effects caused by different types of hydrocarbons.

Effect of Type of Driving

It is generally recognized that severity of driving is a major factor in requirement increase, and the sensitivity of some engines to "clean-up" during severe driving is well recognized. This is not, however, a simple matter of reduction of deposit weight. As an express example of this effect, an engine which is widely used in trucks and passenger cars will accumulate about 80 grams of deposit in passenger car service. The same type of engine in heavy, over-the-road truck service will accumulate about the same weight of deposit on the same fuel and lubricant. The requirement increase in passenger car service will be about 10 units, average, while the truck engine will show little or no increase due to deposits. There is every indication that requirement increase due to deposits is small in most heavy duty operations.

Effect of Torque Converters

Many predictions have been made of the effect of various types of automatic transmissions and fluid drives on the fuel antiknock requirements of engines. The estimates have been based largely on curves of requirement over the engine speed range, obtained with a standard transmission loading the engine in the conventional manner. The assumption has been made that the requirement with the special transmission will be the same as the value obtained with the standard unit at speeds above the lock-up speed. Evaluation in this fashion seemed open to question, hence work was carried out with cars equipped with standard and torque converter drives, to study the effect of the converter on requirement. The torque converter was chosen in preference to the other types of drive since it seemed likely to impose the most drastic change in engine operating condition of any of the units.

Two cars with engines of similar designs but different displacements were used. Requirement of each engine was determined with the torque converter drive and a standard transmission. Duplicate runs were made with both drives and all tests were made on a chassis dynamometer under condi-

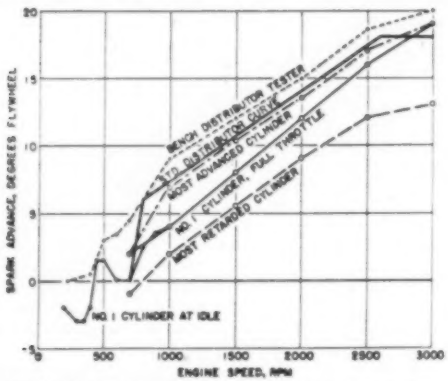


FIGURE 13. Spark Advance Characteristics of Low Octane Number Requirement Engine Make A.

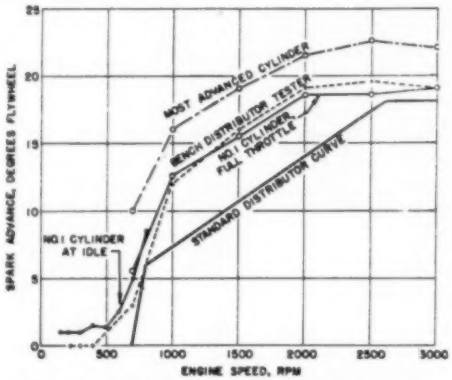


FIGURE 14. Spark Advance Characteristics of High Octane Number Requirement Engine Make A.

tions of constant temperature and humidity to insure a high degree of accuracy. The CRC E-1 requirement procedure was used for all work. Unlike the maximum knock procedure used for the work previously described, the E-1 procedure provides curves of requirement over the speed range of the engine.

Blends of heptane-octane were used to determine the effect of the torque converter on requirement. In addition, a typical commercial premium grade gasoline which nearly satisfied the requirement of the cars was used. The results are shown in Figures 10 and 11. The lower curves show requirement over the speed range in the conventional manner and indicate that the change to the converter, by eliminating loading at low speeds, reduces the maximum requirement of both engines slightly. It should be observed, however, that the maximum requirements were 3-5 units higher than would have been predicted from the curves for the standard transmission.

The upper portions of the figures show audible knock intensity curves for several reference fuel blends and for the commercial fuel, which had Motor and Research octane ratings of 80 and 88 respectively. Considering first Car E in Figure 10, the data for the standard transmission show a reference fuel pattern quite typical of engines which knock at low engine speeds. The commercial fuel knocked at both low and high speed but adjustment of fuel antiknock level, or ignition timing, to reduce maximum knock intensity would have removed the high speed knock entirely. The fuel would be rated as about equal to an 87 octane number reference fuel at 700 rpm., i.e., quite close to its Research rating. It will be observed that the torque converter caused the peak knock intensities of reference fuels and commercial fuels to shift slightly relative to each other and that the commercial fuel would be rated as about 86 octane number, also close to its Research rating. It is obvious that the commercial fuel satisfies the engine equally well with either transmission, although knock in the high speed range is potentially more serious than in the low range.

A similar analysis can be made for Engine EE, Figure 11, except that this engine was free of knock at high speed on the commercial gasoline with the standard transmission and, of course, knocked at high speed with the torque converter. Here too, the engine is equally well satisfied by the commercial fuel with both transmissions.

The conclusion can be drawn, therefore, that while the torque converter changes the knocking pattern of these engines from knocking at low speed to knocking at high speed, a typical commercial fuel that satisfies the engine requirement at low speed with a standard transmission will also satisfy its requirement when a torque converter is used. In passing, it might be noted that work with diisobutylene-heptane blends of higher than normal sensitivity to changes in engine severity indicates that very sensitive fuels may be rated lower at the same engine speeds with the torque converter than with the standard transmission.

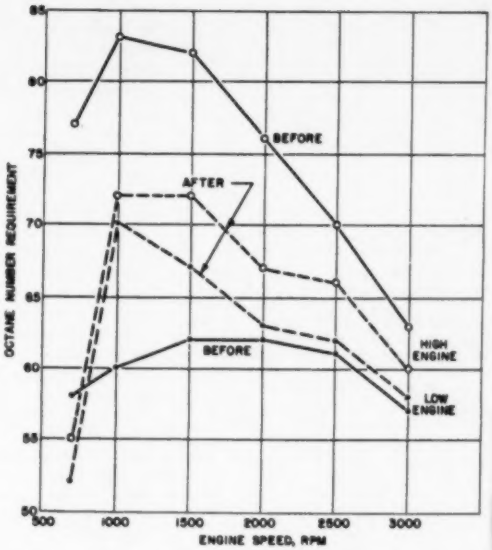


FIGURE 15. Octane Number Requirement of Two Engines, Make A, Before and After Correction for Ignition Timing Characteristics. (Engines tested under equilibrium conditions on dynamometer, "Before" — Ignition timing as received. "After" — Ignition timing adjusted, in most advanced cylinder, to standard curve.)

Effect of Engine Adjustments

The effect of ignition timing on requirement is well understood, but Figure 12, which shows data from a variety of engines, may be of interest. It will be observed that the effect varies from about 0.5 to 1.5 octane units per crankshaft degree, depending to some extent on the octane number level.

Figure 7 was used to illustrate the wide spread in requirement among engines of the same make on the same fuel and lubricant. The high and low requirement engines of Make A were removed from the vehicles at the end of test and installed on an engine dynamometer to search for the reasons why these engines varied so much in requirement. All tests were made with a clean engine and at constant speed under equilibrium operating conditions. It was found that a wide discrepancy existed in ignition timing in the two engines. The data obtained are presented in Figures 13 and 14. Also shown are the standard curve and the results of a check of the distributors on a standard bench test unit.

Considering first the low requirement engine, Figure 13:

1) When timing was set at idle on the basis of No. 1 cylinder, the actual setting would vary by 4½°, depending on the idle speed. In this engine idle speed was about 450 rpm., hence timing was retarded 3°. The peculiar shape of this curve below 600 rpm. was found to be caused by the loose fit of the tongue of the distributor shaft in the groove of the driveshaft. The curve was restored to normal by upsetting the tongue to make a snug fit.
2) The bench test curve was also somewhat erratic at low speed, but parallels the standard curve within reasonable limits. There was relatively little spread (2°) from cylinder to cylinder.
3) There was a spread of approximately 5° between the most advanced and most retarded cylinder when the distributor was installed in the engine. The same cylinders were not the extremes at all speeds and it was observed that the condition was even worse during acceleration although no attempt was made to evaluate its magnitude. The spread was apparently due to whip in the drive system since it could not be eliminated by any distributor change.

Considering the high requirement engine, Figure 14:

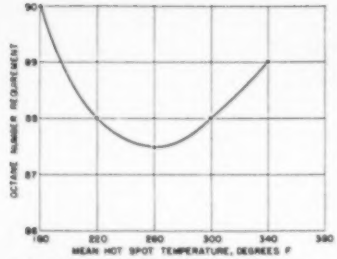


FIGURE 16. Effect of Hot Spot Temperature on Octane Number Requirement. Car E-1. (Temperature measured by thermocouple peened in the intake manifold side of hot spot wall. Value given is average of temperatures at start and end of acceleration from 10 to 60 miles per hour. Change in temperature obtained by change in heat valve spring tension.)

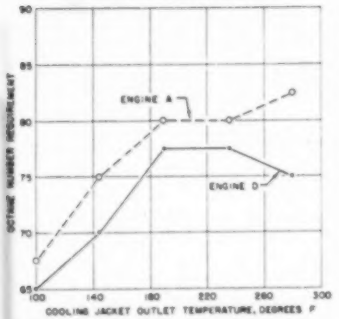


FIGURE 17. Effect of Cooling Jacket Outlet Temperature on Octane Number Requirement. (Engines A and D run at constant speed of 1000 rpm, on an engine dynamometer. All operating conditions except jacket temperature constant. Reference fuels M, C and F.)

1) Idle timing characteristics were normal but basic timing was one degree over-advanced due to an error in setting and an error in locating the timing point marker.
2) The bench distributor test curve was over-advanced approximately 5° at the lower engine speeds.
3) All cylinders were over-advanced on the engine with No. 1 always the most retarded. The most advanced cylinder had an over-advance of 8½° at 1000 rpm., the speed of maximum knock.

The engines were knockrated on the dynamometer by a constant speed Borderline Procedure in the "as received" condition and again with a common distributor but using the most advanced cylinder as an indication of ignition timing. The requirement data obtained are shown in Figure 15. It will be observed that the data obtained in the two engines on a "most advanced cylinder" basis are in close agreement, particularly at the speed of maximum knock at 1000 rpm. Since this agreement was good, it seemed unnecessary to conduct further work on these engines. It might be interesting to point out that both engines developed substantially the same power over the speed range when timing was set for maximum power although there was a 6 percent difference when the engines were run in the "as received" condition.

No claim is made that the variation among the other engines was due entirely to ignition timing; obviously, not all of them could be subjected to this type of investigation. Work on the pairs of high and low engines of the other makes is still in progress.

With the large differences caused by ignition timing in mind, the effects of some other variables may seem to be minor, but are worthy of consideration. For example, intake manifold hot spot temperature may change requirement in terms of reference fuels by several units and relative ratings of fuels by even more. Figure 16 shows requirement data obtained on one engine when hot spot temperature was varied by changing the heat valve spring setting ± ½ turn from standard.

The effect of cooling jacket temperature on requirement is of interest in conjunction with thinking along the line of higher jacket temperatures to provide increased cleanliness to reduce the size of radiator needed for a given engine. Figure 17 shows the effect obtained on two engines, one L-head, and one valve-in-head, operated at constant speed. The cooling system was pressurized to permit use of water as a coolant at all temperatures. Requirement data at 1000 rpm, are plotted in the interests of simplicity. The engines show identical changes from 100 to 235, but diverge somewhat at 270° F. However, it is apparent that any increase in jacket temperature is likely to impose a substantial penalty in increased requirement. The use of coolants having heat transfer coefficients different from that of water would be expected to alter this change, of course.

Conclusion

Figure 18 permits a direct comparison of the average effects on octane number requirement of five of the more important variables discussed in this paper. The changes in the variables shown are of the order that may be expected in normal operation of passenger cars.

Summarization follows:

1) Practically everything with which an engine comes in contact has an effect upon its requirement, hence it is highly unlikely that the Utopia of all engines of a given make and model having the same requirement will ever arrive.

2) Study of the effects of various types of fuels and lubricants offers interesting possibilities for reduction of the requirement increase due to deposition.

3) Variations in requirement from engine to engine can be minimized by careful attention to engine adjustments.

4) Test car data can be made more consistent and reproducible if, in addition to attention to engine adjustments, test work to evaluate requirement is conducted under conditions of substantially constant atmospheric temperature, pressure, and humidity.

It is hoped that the data presented may help in an understanding of the general problem and that the cooperation of the two industries involved may result in better ulitization of the potential performance of fuels and engines.

ACKNOWLEDGMENT

The author wishes to acknowledge the assistance of the people of the Ethyl Corporation, too numerous to mention individually, who have made this paper possible. The author is merely a spokesman for this group, to whom all credit is due.

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[3] Bureau of Standards Research Paper No. 1475 or CRC Handbook, 1946 Edition.

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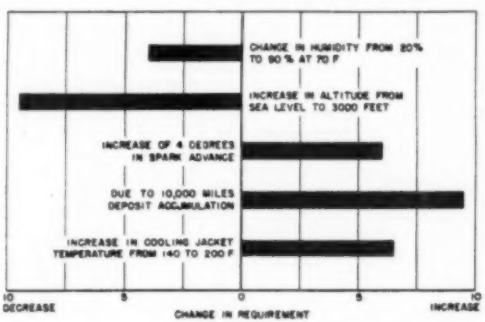
CHANGE IN HUMIDITY FROM 20% TO 90 % AT 70 F
INCREASE IN ALTITUDE FROM SEA LEVEL TO 3000 FEET
INCREASE OF 4 DEGREES IN SPARK ADVANCE
DUE TO 10,000 MILES DEPOSIT ACCUMULATION
INCREASE IN COOLING JACKET TEMPERATURE FROM 140 TO 200 F
10
5
0
5
10
DECREASE
CHANGE IN REQUIREMENT
INCREASE

FIGURE 18. Average Effect of Variables on Octane Number Requirement. (All values based on a normal requirement of 80.)

Various Refinery Applications of Houdriflow Cat Cracking

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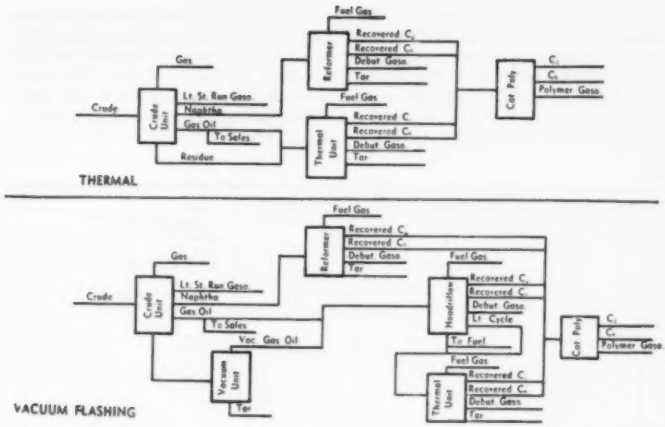


Figure 1. Simplified Flow Diagram for Thermal (above) and Vacuum Flashing (below) Schemes.

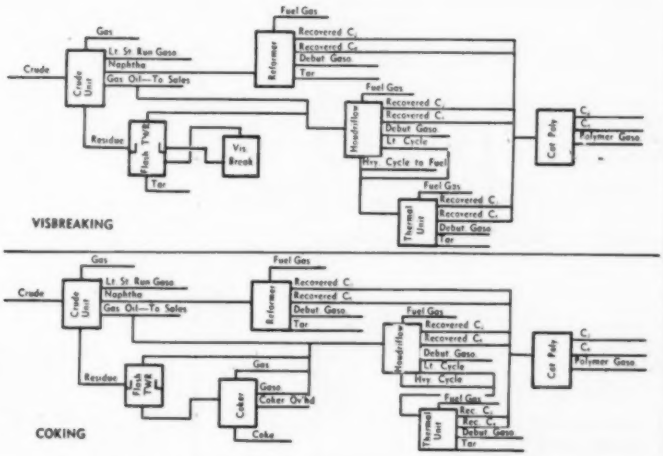


Figure 2. Simplified Flow Diagram for Visbreaking (above) and Coking (below) Schemes.

FOR the purpose of this study four typical methods of refinery operation have been selected. These include thermal cracking, alone, and combinations of catalytic- cracking with vacuum-distillation, visbreaking, and delayed coking of the reduced crude.

The processing schemes covered are listed below and simplified flow diagrams for these schemes are given in Figures 1 and 2:

1) Thermal — This processing scheme consists of conventional two-coil thermally cracking the 40 percent volume East Texas residuum to an ultimate yield of motor gasoline.

2) Vacuum-Distillation — The 40 percent volume East Texas residuum is vacuum-distilled to produce an 8.0 percent volume asphalt. The vacuum gas oil plus the excess light virgin gas oil is catalytically cracked and the catalytic cycle stock remaining after blending the tar bottoms to No. 6 fuel oil specification is thermally cracked.

3) Visbreaking — The 40 percent volume East Texas residuum is charged to a flash tower and the resulting bot-

***THE PURPOSE** of this study, presented at the recent San Antonio meeting of the Western Petroleum Refiners Association, is to review the economics of catalytic cracking as applied to several methods of refinery operation. Right now the petroleum industry is confronted with a difficult problem in the production of distillate and residual fuel, the supply of both of these fuels currently exceeding the demand. Price, too, has dropped, stocks have risen sharply and crude runs to stills have been reduced in some refineries for the first time since the early part of 1946. The best available tool for bringing the production of fuel oil into balance is catalytic cracking. Another factor contributing to an increase in cracking operations is the increase in octane rating, a probable need for the near future since engine designers are experimenting with higher compression engines. At any rate, the sharp drop in the price of fuel oils makes it expedient at this time to re-examine the economics or refinery cracking operations.*

toms is visbroken and returned to the common flash tower. The flash tower overhead stock plus excess virgin gasoil are catalytically cracked and the catalytic cycle stock remaining after blending the tar bottoms to No. 6 fuel oil specification is thermally cracked.

4) Coking — The 40 percent volume East Texas residuum is flash-distilled to obtain an overhead fraction and the resulting bottoms is coked. The combined flash tower overhead and total coker distillate plus excess light virgin gasoil are catalytically cracked and the catalytic cycle stock is thermally cracked.

In order to further this study two additional processing schemes were calculated to show the effect of recycle catalytic cracking instead of thermally cracking the cycle stock. The two addi-

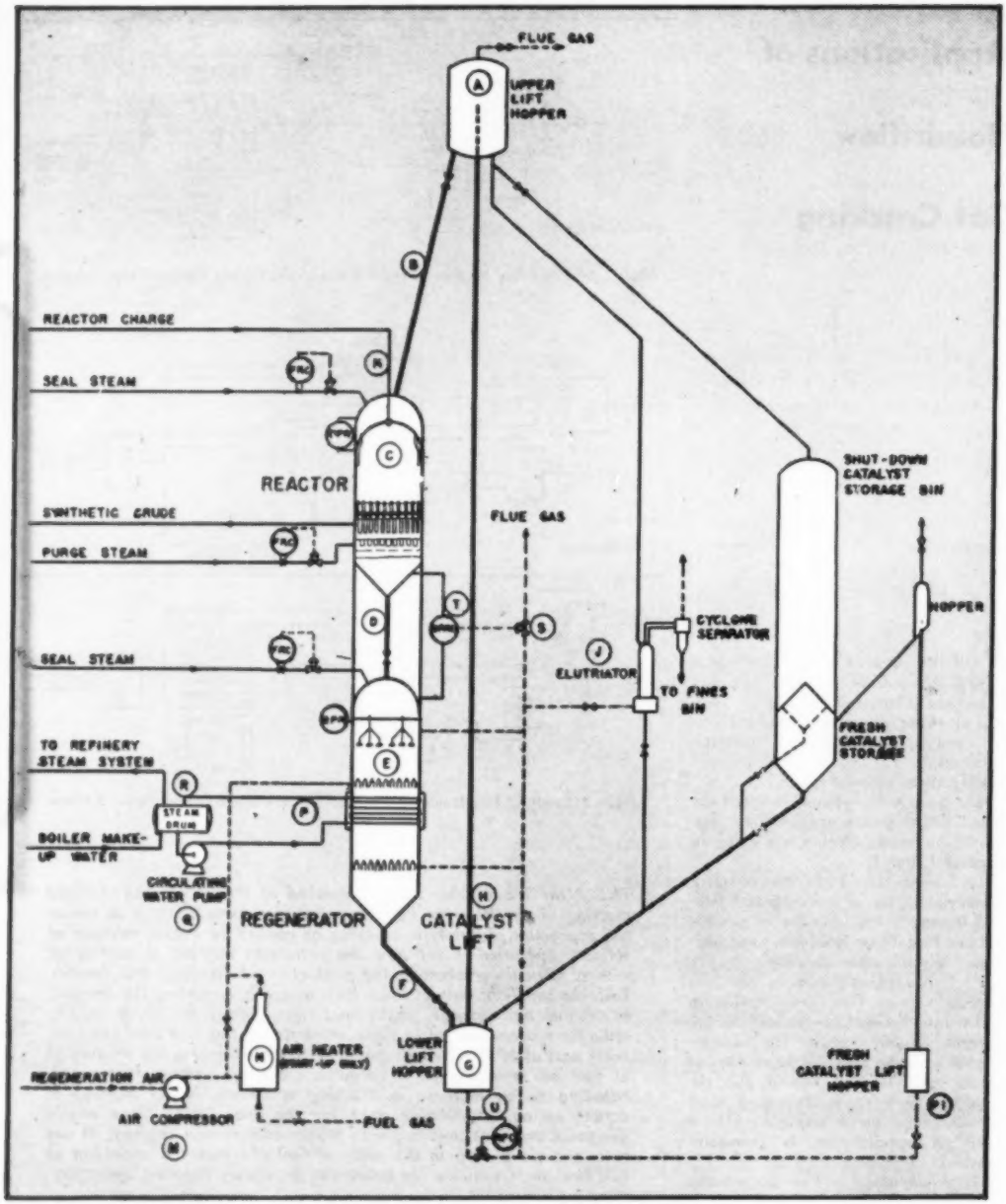


Figure 3. Flow Diagram Houdriflow Catalytic Cracking Process.

tional situations are alternates for the visbreaking and coking processing schemes and are designated 3A and 4A.

The basic yield data on which this survey is based were obtained during an extensive pilot plant program by the Houdry laboratories to determine the effect of method of stock preparation on the catalytic cracking characteristics of the resulting stocks. During this laboratory program stocks were prepared from East Texas reduced crude by coking, vacuum-distillation, and by visbreaking to various severity levels. These stocks were cracked in a pilot catalytic cracking unit. Gasoline and fuel blends were prepared and tested.

In the economic study the crude charge is assumed to be 10,000 B.P.C.D. of East Texas crude. The crude is distilled to obtain a 250° F.-E.P. straight-run gasoline, a 250-400° F. straight-run naphtha, a light gasoil for diesel or No. 2 fuel, and a 40 percent volume residuum. The 250° F.-E.P. straight-run gasoline is used directly in the final motor gasoline blend. The 250-400° F. naphtha is thermally reformed to obtain a 70-octane distillate. It was assumed that 1000 B.P.C.D. of light gasoil goes to sales and the remaining 960 B.P.C.D. is available as catalytic cracking charge stock. The C_3 and C_4 fractions from the thermal and catalytic operations are charged to a catalytic polymerization unit to produce a polymer for use in the motor gasoline blend.

In the economic comparisons Table A contains typical Gulf Coast price structure and utility values which were assumed to be representative of the

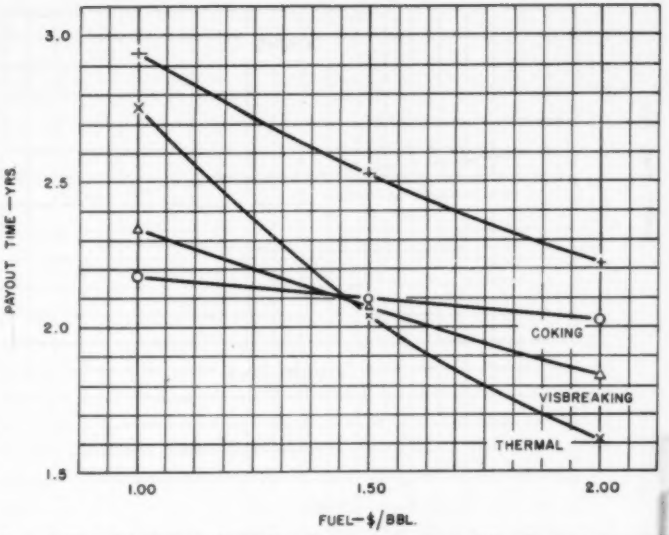


Figure 4. Effect of Fuel Price on Payout Time. Gasoline 11.5 Cents per Gallon. Top curve represents vacuum flash.

TABLE 1

Summary of Economics—Processing 10,000 Barrels per Charge Day, East Texas Crude

Scheme Number		1		2		3		4		3A		4A	
Processing		Thermal		Vac. Dist. Once Thru Cat. Crack.		Visbreaking Once Thru Cat. Crack.		Coking Once Thru Cat. Crack.		Visbreaking Recycle Cat. Crack.		Coking Recycle Cat. Crack.	
Revenue	$/Bbl.	BPCD	$/Day	BPCD	$/Day	BPCD	$/Day	BPCD	$/Day	BPCD	$/Day	BPCD	$/Day
10 lb. RVP Motor Gasoline	$4.830	6,126	29,589	6,694	32,332	6,797	32,830	7,370	35,597	6,745	32,578	7,120	34,390
Diesel Fuel	3.570	1,000	3,570	1,000	3,570	1,000	3,570	1,000	3,570	1,000	3,570	1,000	3,570
No. 2 Fuel	3.570									505	1,803	629	2,246
No. 6 Fuel	1.50	2,378	3,567	1,781	2,672	1,623	2,435	826	1,239	1,024	1,536	243	365
Dry Gas (F.O.E.)	1.50	739	1,109	744	1,116	794	1,191	858	1,287	753	1,130	794	1,191
Excess Butane (As Fuel)	1.05			43	45	65	68	80	84	124	130	130	136
Coke	5.00$/T.								220				220
Total Revenue			37,835		39,735		40,094		41,997		40,747		42,118
Operating Costs:													
Crude	2.93$/B.	10,000	29,500	10,000	29,500	10,000	29,500	10,000	29,500	10,000	29,500	10,000	29,500
Crude Distillation		10,000	772	10,000	772	10,000	772	10,000	772	10,000	772	10,000	772
Houdriflow Cracking				4,157	703	4,272	812	4,767	815	5,544	1,063	9,534	1,093
Gas Plant			238		592		605		654		629		679
Thermal Cracking		4,960	1,089	1,552	489	1,614	500	2,083	585				
Thermal Reforming		1,990	453	1,990	453	1,990	453	1,990	453	1,990	453	1,990	453
Vacuum Distillation				4,000	355								
Coking								1,497	427			1,497	427
Catalytic Polymerization		261	226	338	256	373	261	422	276	373	261	407	272
TEL to 80 O. N. (F-2) (1,000 cc's)	0.22¢/cc	437	962	210	464	228	502	337	742	147	324	203	447
Gasoline Inhibitor		6,241	6	6,694	7	6,797	7	7,370	7	6,745	7	7,120	7
Taxes, Interest, Insurance			401		647		589		695		586		678
Houdriflow Royalty	5.0¢/B.			4,157	208	4,272	214	4,767	238	4,272	214	4,767	238
Thermal Royalty	3.0¢/B.	6,950	209	3,542	106	3,604	108	4,073	122	1,990	60	1,990	60
Cat. Poly. Royalty	21.0¢/B.	261	55	358	75	373	78	422	89	373	78	407	85
Total Operating Costs			$33,911		$34,627		$34,401		$35,375		$33,947		$34,711
Earnings, $/CD			3,924		5,108		5,693		6,622		6,800		7,407
Payout Time, Years			2.04		2.53		2.07		2.10		1.72		1.83
TEL to 78 on (F-2) (1,000 cc's)		283	$ 623	104	$ 229	114	$ 251	186	$ 409	65	$ 143	95	$ 211
Earnings, $/CD			4,263		5,343		5,944		6,955		6,981		7,643
Payout Time, Years			1.89		2.42		1.98		2.00		1.68		1.77
TEL to 82 on (F-2) (1,000 cc's)		669	$ 1,472	388	$ 854	399	$ 878	557	$ 1,226	306	$ 673	389	$ 855
Earnings, $/CD			3,414		4,718		5,317		6,138		6,451		6,999
Payout Time, Years			2.35		2.74		2.22		2.27		1.82		1.94
Investments (Process Equipment Only):													
Crude Distillation			$700,000		$700,000		$700,000		$700,000		$ 700,000		$700,000
Houdriflow Catalytic and Feed Prep.					1,505,000		1,580,000		1,600,000		1,900,000		1,980,000
Vacuum Unit					500,000								
Gas Plant			680,000		775,000		800,000		840,000		825,000		850,000
Thermal Cracking and Reforming			1,180,000		800,000		800,000		880,000		400,000		400,000
Catalytic Polymerization and Feed Treating			370,000		440,000		450,000		485,000		450,000		470,000
Coker									570,000				570,000
Total			$2,930,000		$4,720,000		$4,300,000		$5,075,000		$4,275,000		$4,950,000

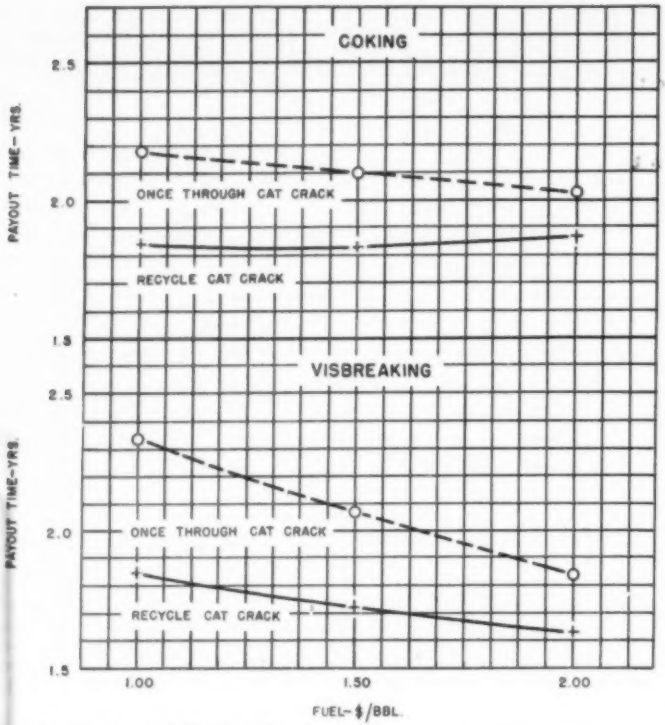


Figure 5. Comparison Once-Through and Recycle Catalytic Cracking on Payout Time.

TABLE A

STOCK	Price
East Texas Crude, Barrel	$2.95
Motor Gasoline, Gallon	0.115
Diesel Fuel, Gallon	0.085
No. 2 Fuel, Gallon	0.085
No. 6 Fuel, Barrel	1.50
Butanes, Gallon (Fuel Value)	0.025
Fuel Gas, MM B.t.u.	0.25
Steam, M Lbs.	0.35
Power, K.W.H.	0.008
Water (Cooling), M Gallons	0.005
Water (Treated), M Gallons	0.15
Clay Catalyst, Lb.	0.05

prices existing at this time. Individual refiners should substitute their own price structure in order to determine their particular economics.

The over-all maintenance cost for the processing equipment was assumed at 4.0 percent of the investment. The taxes, interest, and insurance costs were estimated at 5.0 percent of the investment. The royalty rates were assumed to be 5 cents per barrel of fresh feed for catalytic cracking, 3 cents per barrel of fresh feed for thermal cracking and reforming, and 0.5 cents per gallon of polymer for the catalytic polymerization.

It should be pointed out that the investments are for the primary processing equipment. No storage or offsite auxiliary facilities have been included. Consequently, net earnings are purely comparative.

The features of the main types of processing equipment are as follows:

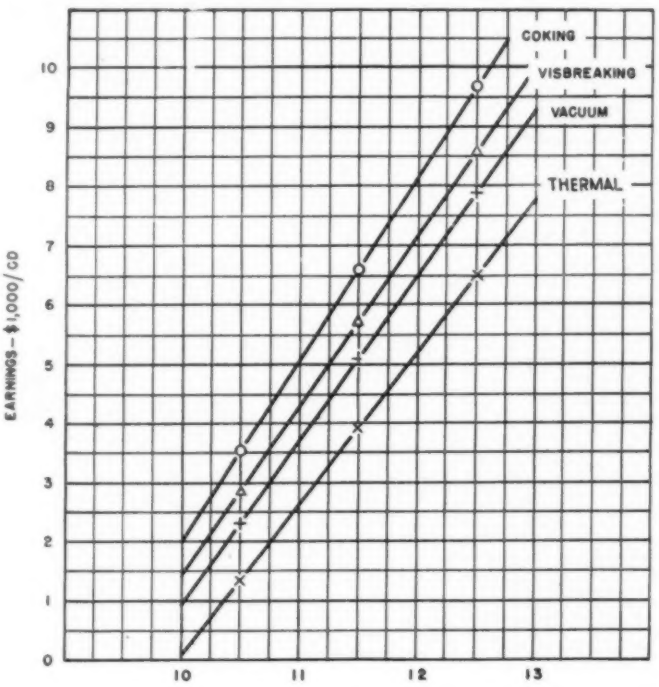
1) Thermal Cracking—A conventional two-coil thermal cracking unit was assumed to handle the East Texas residuum with provision for visbreaking the residuum and cracking the light oil.

2) Vacuum-Flashing—The reduced crude is flashed in a conventional vacuum tower and the vacuum gasoil is charged to the catalytic unit.

3) Visbreaking—In order to minimize the investment by eliminating a flash tower, an integral type flow is used. The reduced crude is charged to a flash tower and the resulting bottoms is charged to a visbreaker heater and then to the common flash tower. The combined vapor from the flash tower is charged to the catalytic unit.

4) Coking—A drum type delayed coking unit is used and the charge is the 15 percent volume residuum from flashing the 40 percent East Texas residuum in an atmospheric flash tower. The coker overhead products combine with the flash tower overhead for

Figure 6. Effect of Gasoline Price on Earnings. Basis: Fuel, $1.50 per Barrel.



processing in the catalytic equipment.

5) Houdriflow—In all of these studies the new Houdriflow catalytic cracking process is used.

This catalytic cracking process, shown in Figure 3, retains the desirable features of the conventional TCC process and in addition a number of improvements have been made which result in greater flexibility and lower cost. These improvements include a new method for moving catalyst, the use of higher catalyst to oil ratios, a simplified kiln and a more compact physical arrangement of the vessels.

The use of flue gas for lifting catalyst is more attractive than the bucket elevators in that it is cheaper, decreases the number of mechanical devices, and permits a wider range of catalyst circulation rates.

The use of a higher catalyst to oil ratio permits considerable flexibility in operation in that liquid, partially vaporized, or vaporized stocks may be processed without difficulty. The use of liquid or partially vaporized stock simplifies the feed preparation equipment since a major portion of the reaction heat can be supplied by the catalyst entering the reactor.

The simplified kiln is the result of the increased catalyst circulation. One or two burning zones are sufficient as compared to 7 to 10 zones in previous designs.

The reactor is superimposed on the kiln in order to minimize catalyst handling and to reduce the ground area requirement.

Regenerated pelleted or bead catalyst in the upper lift hopper flows by gravity through the reactor seal leg into the reactor. The catalyst passes downward through the reaction zone, through vapor-disengaging and steam-purging sections in the bottom of the reactor. It then goes by way of the seal leg into the distributing head of the kiln. The spent catalyst flows into the kiln proper through a distributor, designed to insure uniform distribution, and continues downward through the regenerator.

Leaving the bottom of the kiln, the catalyst flows by gravity through a seal leg into the lower lift hopper from which point it is transported by means of flue gas from the kiln through a vertical lift pipe into the upper lift hopper. As in the conventional TCC process a small stream of catalyst is continuously by-passed to the elutriator where "fines" are removed by air classification to maintain the average particle size of the catalyst in the system at the desired value.

The oil charge enters the reactor through an injection nozzle, located centrally in the top of the reaction zone and inside the annular curtain of flowing catalyst. By means of the injection nozzle the mixed-phase feed is atomized and directed onto the annular curtain of hot catalyst which immediately completes the vaporization of the charge and brings the temperature of the vapor-catalyst mixture to the desired level for reaction. The hydrocarbon vapors then pass downward concurrently with the catalyst through a solid-bed reaction zone.

The cracked vapors or synthetic crude leave the reaction zone via a catalyst-vapor disengager in the lower part of the reactor and flow to a conventional fractionation and recovery plant.

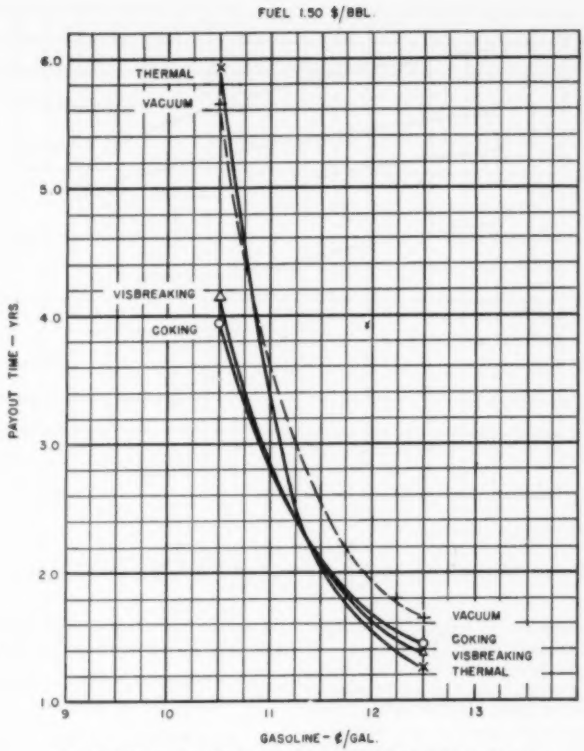


Figure 7. Effect of Gasoline Price on Payout Time. Fuel, $1.50 per Barrel.

TABLE B

Scheme No.	Processing	Investment	Payout Period Years	Earnings $/CD	No. 6 Fuel Produced Percent on Crude	c.c. T.E.L. to 80 O.N. Motor
1	Thermal	$2,930,000	2.04	3,924	23.78	1.7
2	Vacuum-Distillation	4,720,000	2.53	5,108	17.81	0.75
3	Visbreaking	4,300,000	2.07	5,693	16.23	0.80
4	Coking	5,075,000	2.10	6,622	8.26	1.09
3A	Visbreaking—Recycle Cat. Cracking	4,275,000	1.72	6,900	10.24	0.52
4A	Coking—Recycle Cat. Cracking	4,950,000	1.83	7,407	2.43	0.68

TABLE C—Lead Requirement

Scheme No.	Processing	Lead Requirement, cc/Gal.			
		78 O.N.	80 O.N.	82 O.N.	84 O.N.
1	Thermal	1.1	1.7	2.6	...
2	Vacuum-Distillation	0.37	0.75	1.38	2.15
3	Visbreaking	0.4	0.8	1.40	2.2
4	Coking	0.6	1.09	1.8	2.95
3A	Visbreaking—Recycle Cat. Cracking	0.23	0.52	1.08	1.7
4A	Coking—Recycle Cat. Cracking	0.32	0.68	1.30	2.0

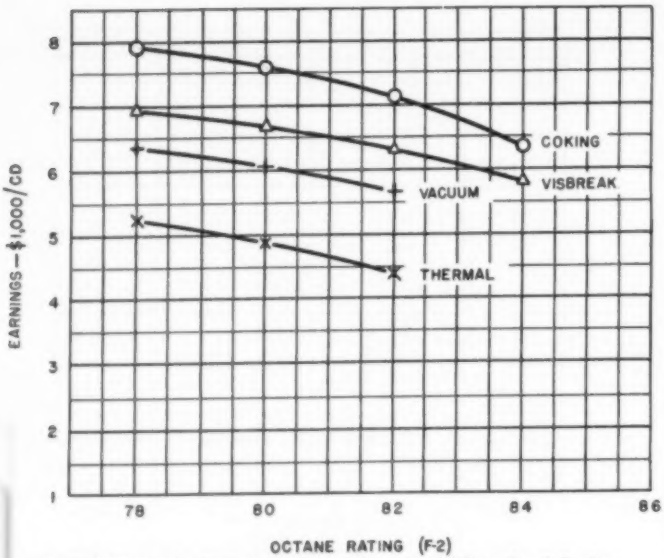


Figure 8. Effect of Octane Rating on Earnings. Basis: Fuel, $1.50 per Barrel. Gasoline 11.5 Cents per Gallon.

A small flow of steam into the head of the reactor, automatically regulated by a recording flow controller, maintains a seal at the top of the reactor to prevent the escape of hydrocarbon vapors up the seal leg and, similarly, the purge steam in the bottom of the reactor precludes the possibility of escape of cracked vapors through the seal leg into the regenerator.

Air for regeneration of the spent catalyst, supplied by a blower at about 10 psig., by-passes the air heater which is used for start up only, and enters the kiln through a channel-type distributor. Flue gases from the upper burning zone disengage above the catalyst distributor, leave the top of the regenerator, and enter the main flue gas duct. Flue gases from the lower burning zone leave the bottom of the regenerator by way of a channel type collector and also enter the main flue gas duct. A bank of cooling coils in the kiln removes regeneration heat as steam to maintain the desired catalyst temperatures.

The flue gas for the catalyst lift enters the lower lift hopper through a flow controller, engages and carries the catalyst up the lift pipe to the upper lift hopper, and from this point is vented to the atmosphere.

A summary of the relative advantages of the various processing schemes when producing a gasoline having an 80 F-2 octane rating is given in Table B.

The summary indicates that at the present gasoline prices and provided the refiner has a market for coke the delayed-coking process is a very attractive method for preparing catalytic cracking feed stocks. Although the coking scheme results in the largest investment, the pay-out time compares very favorably with the other processes and the earnings per day are appreciably higher than for the other processes. Visbreaking compares favorably with the coking process in that it has a lower investment, slightly lower pay-out time, but produces lower earnings. Recycle catalytic cracking of the cycle stocks (Schemes 3A and 4A) indicates reduced pay-out times and higher earnings over once-through catalytic cracking followed by thermal cracking of the net cycle stocks after fuel blending. Complete investment, operating costs, and earnings are summarized in Table 1. Basic yield data for the various operations are shown in Tables 2, 3 and 4.

The effect of the price of residual fuel on the pay-out time with once-through catalytic cracking and with recycle cracking is shown in Figures 4 and 5. Variation in the fuel price produces the greatest effect on the earnings of the processing schemes producing the most residual fuel. The coking scheme is the least affected by the price of fuel. Recycle catalytic

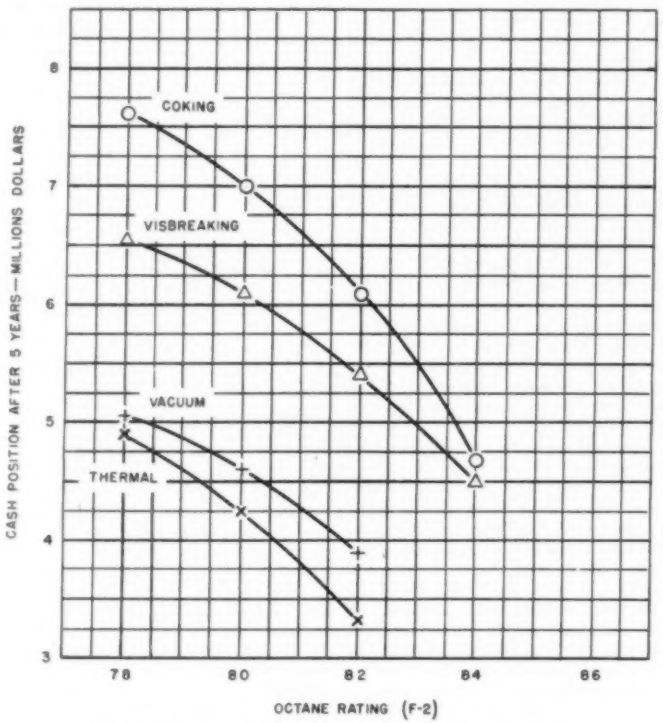


Figure 9. Effect of Octane Requirement on Cash Position after Five Years. Basis: Fuel, $1.50 per Barrel. Gasoline, 11.5 Cents per Gallon.

cracking minimizes residual fuel when compared to once-through catalytic cracking followed by thermal cracking of the catalytic cycle stock. The recycle operation is affected less by the price of fuel and shows considerable advantage over once-through cracking.

As the gasoline price increases, with fuel price remaining constant, the advantage of the coking, vacuum-flashing, and visbreaking over thermal cracking increases. The differential earnings between the various processing schemes are only slightly affected by substantial changes in gasoline price. This is illustrated in Figures 6 and 7.

The lead requirements for the motor gasoline blends vary appreciably depending on the method of processing. A brief summary of the lead requirements is shown in Table C.

On the basis of this summary it is apparent that as the octane level is increased the advantage of catalytic cracking over thermal cracking increases. The advantage of coking over visbreaking decreases because of the higher lead requirement. The higher lead requirement is the result of the lower octane of the coker gasoline.

If the lead content of the gasoline had been held constant and the octane difference corrected by the amount or severity of naphtha-reforming, the relative advantage of catalytic cracking over thermal cracking would be enhanced.

The influence of the octane rating requirement of the motor gasoline on the economics is shown in Figures 8 and 9. The lead requirements for the various gasolines are presented in Figure 10.

Conclusions

The studies as presented indicate the following conclusions:

1) At the present market conditions, coking or visbreaking are the best methods for preparing catalytic cracking charging stocks.

2) More catalytic cracking capacity appears necessary because of the octane advantage of catalytic over thermal gasolines.

3) To minimize the production of residual fuel, the use of catalytic cracking is advantageous.

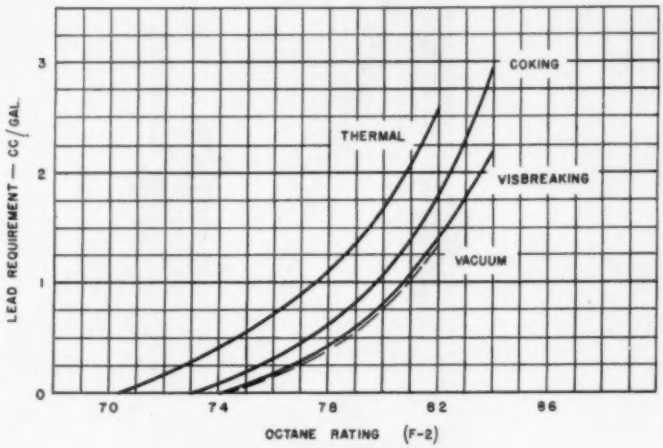


Figure 10. Lead Requirement vs. Octane Rating.

TABLE 2
Thermal Reforming Yields

Scheme Number	1-6
Charge to Unit, BPCD:	
250-400° F. Naphtha	1,960
Yields Based on Charge, Percent Volume:	
Debut. Gasoline	73.5
Fuel Oil	3.0
Isobutane	1.5
Normal Butane	2.3
Butenes	5.4
Propylene	5.1
Dry Gas (C_2 + Lighter), percent weight	15.3
Octane Ratings (F-2):	
Charge	46.0
Product	70.0

TABLE 4
Thermal Cracking Yields

Scheme Numbers	1	2	3	4
Charge Stock, BPCD:				
Diesel	960			
Reduced Crude	4,000			
Catalytic Gas Oil		1,552	1,614	2,082
Total	4,960	1,552	1,614	2,082
Gravity, °API	24.8	28.5	26.9	27.6
Yields—Percent Volume:				
Debut. Motor Gasoline	43.4	47.5	47.7	47.1
Isobutane	1.8	1.4	1.4	1.4
Normal Butane	1.4	2.2	2.4	2.3
Butenes	2.6	3.6	3.6	3.6
Propylene	2.1	3.0	3.0	3.0
Fuel Oil	46.7	36.5	37.1	36.8
Dry Gas (C_2 + Lighter), Percent Weight	8.3	12.5	12.5	12.5

TABLE 3
Houdriflow Catalytic Cracking Yields

Scheme Numbers	2	3	4	3A	4A
Charge to Unit, BPCD:					
Diesel Fuel	960	960	960	960	960
Flash Tower Overhead—					
Virgin	....	2,504	2,504	2,504	2,504
Visbreaker	....	808	....	808	....
Coker Overhead	....	....	1,303	....	1,303
Vacuum Gas Oil	3,179	....	....	....	....
Recycle	....	....	....	4,272	4,767
Total	4,157	4,272	4,767	8,544	9,534
Yields Based on Fresh Charge, Percent Volume:					
Debut. Motor Gasoline	42.0	41.8	43.2	50.0	50.4
Catalytic Gas Oil	45.8	44.3	43.7	18.2	18.3
Isobutane	5.0	5.1	5.1	7.4	7.1
Normal Butane	1.8	1.9	2.0	2.7	2.7
Butenes	4.3	4.3	4.3	5.5	5.6
Propylene	2.6	2.9	3.2	4.3	4.4
Dry Gas (C_2 + Lighter), Percent Weight	5.9	6.8	6.2	10.7	10.5
Carbon, Percent Weight	4.6	5.0	5.5	8.4	9.5
Carbon, #/Hr. (Stream Day)	2,710	3,020	3,717	5,140	6,480

* * *

Above—Rigger bolting the ladder to the demethanizing column at McCarthy Chemical Company's new gasoline plant, Winnie, Texas. The remaining column to be raised to the left of the demethanizer is the absorber, which had not been moved into the site due to the mud.

(All photos by C. C. Pryor, associate editor.)

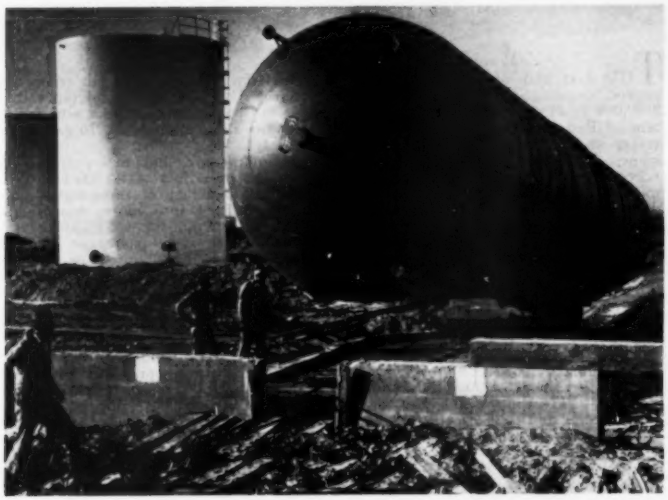
McCarthy Chemical Builds Second Gasoline Plant Despite the Mud

CONSTRUCTION of a gasoline plant, in its simplest form is a complicated and difficult procedure from initial design to the final round of painting. Actual construction work requires close cooperation between all the groups concerned for equipment, foundations, rigging, piping, welding, and the 101 other operations involved.

To the usual and ordinary run of difficulties, add more than a month's almost continuous heavy rains, and the resulting quagmire of black gumbo and yellow clay becomes the subject of the project engineer and construction superintendent's worst dreams by night and the objective of his foulest imprecations

Rigging crew preparing to skid storage tank from railroad siding to storage site. Deep mud made use of rubber-tired bolster impossible, so crew rigged sled of steel plate. Using winch truck at left, tank was rolled up incline of heavy timbers and balance on sled cribbing. A stationary winch about 600 feet in front of the sled is used to pull the sled over the mud to the plant site.

Loaded on the sled, the tank was turned 90 degrees and chained to the sled. The tank is headed in the same direction as the winch truck at the right. In the background of the photograph is the chemical plant and gasoline plant No. 1.



The tank has been skidded down the mud runway to the concrete foundation piers. At this point the tank is pulled over the foundations shown here, and the head end placed on a bolster between the piers. A dragline lifts the rear end and the tank is moved forward on the bolster until it is across the piers. Then the tank is rolled across the piers on timbers until it reaches its place. The ends are raised by the dragline for the saddles, which are lifted in place by the rigging crew, and the tank is ready for piping and painting.

by day. The riggers just called it names we can't print and went to work.

Such were the working conditions under which construction crews have shown progress in the erection of a second gasoline plant, to be operated in conjunction with the existing gasoline plant and the recently completed petrochemical plant of McCarthy Chemical Company at Winnie, Texas.

Heavy rains turned the plant site into a veritable mudhole, which not only prevented movement of equipment by trucks and tractors, but made it impossible for the men to walk in the area without becoming mired. A few days sunshine dried the surface of the mud to a treacherous crust, which would break through to deposit the unwary worker in knee-deep mud so gummy he needed assistance to get out.

Construction was brought to a near standstill by the mud until board roads (four layers thick) were laid throughout the plant area. More than 80 percent of the work resumed when the roads had been laid. However, it will be noted in the accompanying photographs that the riggers had not been able to move all the heavy vessels into the area and raise them before "the great deluge." That portion of the work was still to be done—in the mud. One rigging crew, tired of fighting the mud, actually managed to use it in skidding storage tanks on a sled from the railroad siding to their foundations.

The new plant, having the same capacity as the first plant constructed, will process 85 million cubic feet daily of natural gas from the North and South Stowell, Fig Ridge, Winnie, and Fannett fields. Products extracted from the gas will include propane, butane, naphtha, kerosine, gasoline, and fuel oil. Residue gas from the plant will be used as raw material in the chemical plant.

Process for the new plant was designed by Petroleum Engineers, Inc.; rigging and erection was contracted by Westheimer Rigging Company, and foundation and piping by Carruth Construction Company. Construction drawings were supplied by Wyatt C. Hedrick.

As shown in the photographs, condensers, heat exchangers, accumulators, and accessory equipment are supported in a steel structure of the type used in refineries. The ground floor of the structure will serve as the pump room. The structure is designed to increase the compactness and accessibility of equipment for operation. Also, pumps below the structure are provided with the required head for efficient performance.

Vessels used in the process include a 1000-pound absorber; 500-pound reabsorber, 24 trays; 185-pound reabsorber, 24 trays; high pressure still, low pressure still, deethanizer, depropanizer, debutanizer; distillate still (200 endpoint); demethanizer, and a naphtha still.

Process area of the plant, completion of which was slowed by heavy rainfall. Until the board roads were laid, deep mud prevented trucks moving heavy equipment onto the site. The steel structure behind the row of columns is similar to that used in refineries and will support the condensers and accumulators for the various columns. Process pumps are beneath the structure on the ground level. Three columns of plant No. 1 can be seen at the right.

"FIDO" Offers Further Use And Market for Diesel Fuel

One of 392 fog-dispersing "triads" shown in test burn at Los Angeles Airport. Flames rise about 12 feet and fan out about 9 feet at top to give controlled heat which causes the atmosphere to absorb water.

THE first unit of the new and improved commercial installation of the $842,000 Todd thermal fog dispersal system ("Fido") has been successfully tested at the Los Angeles airport. Designed to improve airline safety and schedule regularity, it is the first commercial installation in the world and was developed by Todd Shipyards Corporation. The city combined with the CAA to finance the construction under the Federal Airport Act. However, the five major airlines serving Los Angeles have underwritten operating cost and maintenance and have contracted to amortize the city's $385,541 of capital expenditure, over a five-year period.

The installation is designed to produce ceiling heights as follows: a) 400 to 300 feet in the 2000-foot approach zone; b) 250 feet in the 1000-foot "touchdown" zone, and c) 200 feet to 75 feet in the 3000 feet of remaining runway.

There are 392 "triads" on frames erected 14 inches above the ground which parallel both sides of the main east-west runway and approach zone for 6000 feet. Every triad has three Todd jet-atomizer nozzles that control the combustion of diesel fuel. The triads are connected with underground pipes that lead to two oil storage tanks, situated in a remote area, holding 129,276 gallons of fuel each.

Estimates are that this system will turn 75-foot ceilings into 300-foot ceilings, and visibility of three-eights mile can be turned into more than three-quarters of a mile in two minutes at a cost of $200. A 50-passenger airplane can probably "Fido" into Los Angeles for about $3 per passenger. This compares with $8 to $10 per passenger which it costs when planes use the alternate field at Palmdale, on the desert near Los Angeles.

The Todd jet-atomizers are ignited instantaneously by push-button control from a control booth through electrical dual igniters on the frame holding the triads. The rate of output of fuel can be varied by controlling the pressure in the return line without affecting the quality of atomization and without changing the oil supply pressure. The angle of flame is practically constant over the entire range of fuel output. Burners can be immediately shut off to eliminate drip and to assure minimum required operation.

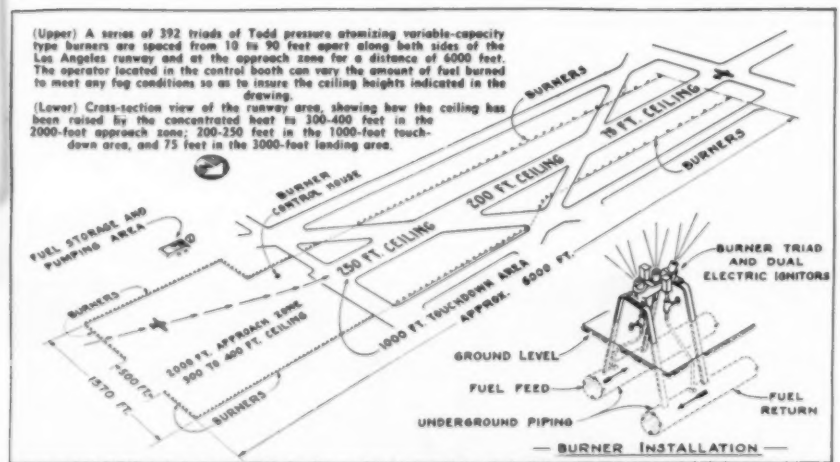
The intense controlled heat generated raises the saturation point of the atmosphere to absorb water vapor over and in the immediate vicinity of the runway. The installation is designed to disperse the densest fog in 1½ minutes to a minimum operable ceiling height.

Burning lines parallel both sides of the main runway for 4000 feet and then fan out into the approach zone for 2000 feet where they "hook" left and right to form burning patterns which take full advantage of wind drift normally associated with fog. Separation of burning lines range from 400 to 870 feet from the center of the runway.

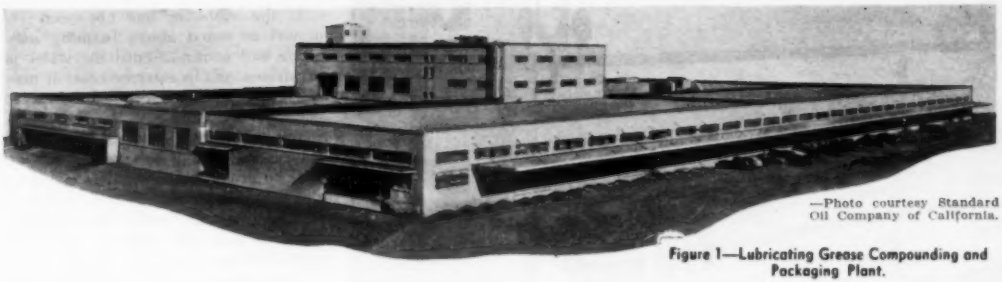
Construction at Los Angeles was by Bechtel Corporation, prime contractors.

(Upper) A series of 392 triads of Todd pressure atomizing variable-capacity type burners are spaced from 10 to 90 feet apart along both sides of the Los Angeles runway and at the approach zone for a distance of 6000 feet. The operator located in the control booth can vary the amount of fuel burned to meet any fog conditions so as to insure the ceiling heights indicated in the drawing.

(Lower) Cross-section view of the runway area, showing how the ceiling has been raised by the concentrated heat to 300-400 feet in the 2000-foot approach zone; 200-250 feet in the 1000-foot touchdown area, and 75 feet in the 3000-foot landing area.



FOG
2000 FT. APPROACH ZONE
1000 FT. TOUCHDOWN AREA
3000 FT. RUNWAY
BURNER TRIADS 12 TO 27 FT APART
BURNER TRIADS 10 TO 90 FT APART



—Photo courtesy Standard Oil Company of California.

Figure 1—Lubricating Grease Compounding and Packaging Plant.

The Manufacture of Lubricating Greases

Part IV. Aluminum and Barium-Base Greases

C. J. BONER
Chief Research Chemist,
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PREVIOUS articles failed to mention the importance of having equipment free of all other types of lubricating grease when a new type is to be manufactured. Due to the particular lubricating greases about to be described, this point must now be stressed.

A number of patents call for the use of soaps of two or more metals in the same lubricating grease, but a general rule for such combinations is that the resulting product takes on the characteristic of the least desirable soap. With some types of lubricants such mixtures may do little harm. Thus, a little sodium soap in a calcium-soap grease or a little calcium soap in a sodium-soap grease will have little adverse effect. On the other hand, other types of soaps in either aluminum-base lubricating greases or barium-base lubricating greases will be detrimental. Therefore, extreme care should be used to see that equipment is free from all other types of greases before manufacturing either aluminum or barium-base lubricating greases.

***PREVIOUSLY** in this series, which seeks to present a thorough review of present day greasemaking practices, the author has discussed calcium and soda-base greases. Now he turns to aluminum and barium-base greases, describing procedures in the manufacture of each as well as actual machinery requirements. The next part, fifth and last of the series, will discuss lithium-base and miscellaneous greases.*

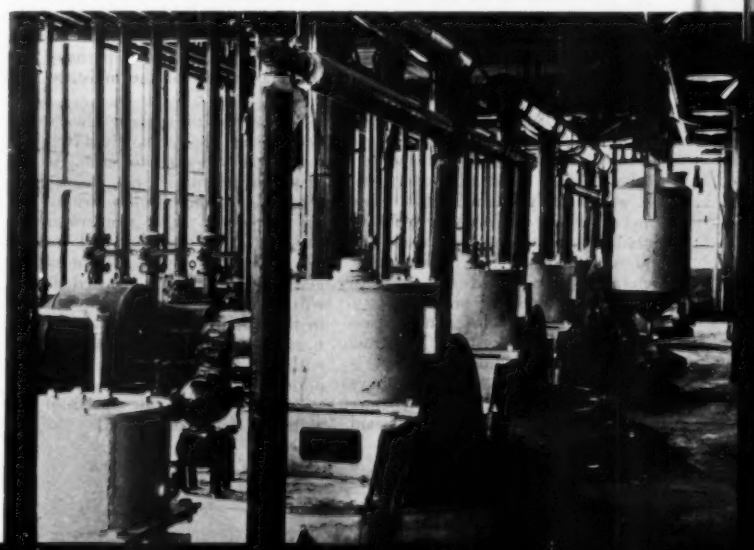
Aluminum-Base Lubricating Greases

In spite of the fact that aluminum-base lubricating greases demand some premium in price over that charged for either calcium or sodium-base lubricating greases a large tonnage of the former is produced. This is primarily because their clarity gives these products a very attractive appearance. Other distinctive characteristics are that due to a lower soap content, they contain about five percent more mineral oil than most calcium-base greases of the same consistency and that many of them have a tacky nature. If a light colored oil is used in the manufacture of such lubricating greases the product will be clear enough so that a newspaper can be read through a one inch thickness of the lubricant. On the other hand, if made from bright stocks the outer tone will be green with a red color by transmitted light. This type of grease has been manufactured for more than 20 years.

Lubricating greases made from aluminum soaps are relatively waterproof and have dropping points slightly higher than calcium-base lubricating greases. When subjected to heat these products become rubbery when near the melting point.

This type of lubricating grease is made almost universally from preformed soap, generally aluminum stearate. There are many manufacturers of this soap and each manufacturer produces several different grades. This is possible because, since aluminum is a trivalent metal, it is possible to combine varying propor-

Figure 2—Series of Compounding Kettles for Lubricating Grease.
—Photo courtesy, Sinclair Refining Company.



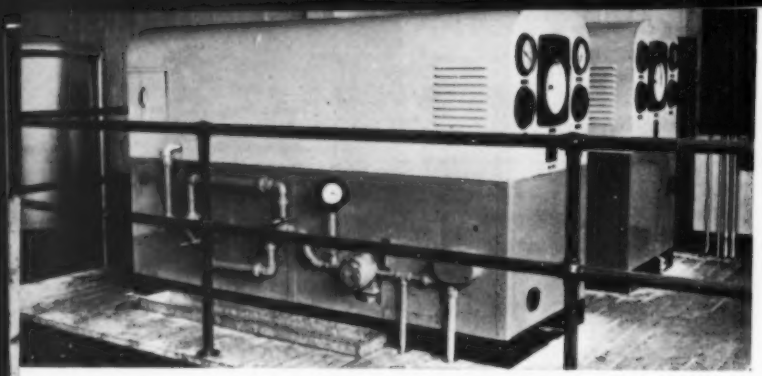


Figure 3—Heating and Cooling Cylinders for Continuous Processing.

tions of metal with fatty acids. The resulting products will then act quite differently when used as gelling agents for mineral oils.

The uniformity and characteristics of dispersions of aluminum soaps in mineral oils depend not only upon the composition of the soap but also upon the type of mineral oil used, additives employed, if any, the method of dispersion of the soap, the amount of moisture in both the soap and the oil and the rate and manner of cooling the resulting lubricating grease. Paraffinic oils will produce more transparent aluminum-base lubricating greases than naphthenic or asphaltic types of oils. High-viscosity oils have greater solvent power for aluminum soaps than low-viscosity oils and hence produce softer products.

Additives and modifiers may be added by the soap manufacturer or they may be introduced when a batch is charged. Some material is termed an additive when it provides a characteristic in addition to that produced by the soap alone. On the other hand a modifier is a product which actually influences and changes the grease structure.

An illustration of an additive is a linear polymer of isobutylene with an average molecular weight in excess of 30,000. Such a product adds additional stringiness to the lubricating grease. Various fats and fatty acids act as modifiers for aluminum lubricating greases in that they make the grease more plastic. High-molecular-weight alcohols, when used in moderation, will also modify aluminum-grease structure. From 5 to 25 percent of an aluminum soap of an unsaturated fatty acid used with 95 to 75 percent of aluminum stearate will also enhance stringiness of the final product.

Aluminum-base lubricating grease is one in which the crystal or gel structure must form while the mass is dormant. While some of the above modifiers may influence this structure formation, no substitute for a dormant or gelling period has so far been discovered.

Batch Formation

In the manufacture of a batch of aluminum base lubricating grease a portion of the mineral oil and the required amount of soap is added to a kettle provided with some means of heating. The agitators are started at once and the soap powder beaten into a cream before heat is started. If more than one speed is provided the agitators are run in high during this period. If this is not done lumps of the soap may remain and once the soap starts to melt the outside of these lumps will fuse and they will remain as lumps throughout the cooking. Any type of heat will serve for the manufacture of aluminum-base lubricating greases and probably the greater portion produced are made in steam jacketed kettles.

Since no chemical reaction is involved, formation of the soap-oil fusion simply consists of dispersing the soap in the oil by heat. When heating is started consideration must be given to the presence of moisture in either the soap or the oil. If the batch reaches the gelling temperature with such moisture present a soft consistency in the final product will result. To correct this the charge can be held at 170 to 185° F. for perhaps two hours and most of the moisture will escape.

By the time the mass reaches a temperature of approximately 170° F. a flabby gel will start to form. At this point the mixture is not clear, probably due to some soap which is still not dispersed. At a temperature of about 200° F. the mass will start to become clear but will still be a weak gel. When 225° F. is reached the gel will be quite heavy and will continue in this condition until at about 325° F. thinning will occur but the mixture will still be quite viscous. When the period of heavy gel arrives it will be necessary to shift the speed of the agitators to low or second.

If the moisture has not been removed as noted above foaming may occur and continue until the water is all driven off. In extreme cases it may be necessary to shut off the heat to check such foaming. When danger of foaming is past the remainder of the oil can be added. Frequently this oil will be preheated in order to speed up the finishing of the charge. Additives or modifiers are added in sufficient time so that they will be throughly mixed before cooking is complete.

After the charge has reached a temperature of about 300° F. it is ready to cool so that a plastic product will result. This cooling may be done in several ways. Many grease plants prefer to pump or draw the grease into shallow pans where it is left undisturbed until the gutty structure has changed to a plastic gel structure. The pans are 3 to 6 inches in depth and are stacked in tiers on racks so that air can circulate around them. One plant has a mechanical device to tilt a series of pans at the same time so that the contents will discharge into a hopper. The consistency of the resulting lubricating grease will vary with the rate of cooling and consequently some plants provide air-conditioned rooms so that they will obtain rapid cooling at a uniform rate. Others provide a rapid change of air around the pans by means of fans. If the grease is pan cooled it is finally emptied into hoppers connected to pumps and screens through which it is forced and delivered to packages. Just previous to this latter step entrained air may be removed by vacuum. In lubricating greases which are sold with clarity as a talking point the presence of air of course detracts from the appearance and therefore many plants use homogenizers for deaerating.

As a consequence of the time involved in pan cooling and because of the space taken up with such pans, much thought has been given to other methods of cooling. One plant cools in a kettle by means of water in the jacket, reducing the temperature from 290° to 163° F. in a little over a half hour, at which point the produce is packaged. If naphthenic type mineral oil is used, the product, after further cooling in the package is fairly uniform in consistency. Using the same procedure but employing a paraffin base oil, a grainy product results. To correct this the time taken to cool a charge is increased to two hours or longer. Other plants draw the lubricating grease directly into packages at temperatures of approximately 230° F. To permit such handling the aluminum soap used has to be modified and even then the product filled in large con-

tainers will be softer in the center than at the edges.

In another procedure the total aluminum soap and half of the mineral oil required are heated together and drawn into pans. This "stiff grease," when cooled, is emptied into a kettle and mixed in the cold with the remainder of the oil. Following this the mixture is fed to a cold homogenizer where a final smoothing out and blending of the heavy lumps and the oil takes place.

Continuous Process

Several installations of a process are in use which provide for heating and then cooling an aluminum soap-oil mixture in a stream so that 1500 to 2000 pounds of material is processed per hour (see Figure 3). A slurry of the soap, oil and additives is prepared and then subjected to a vacuum of 22 to 26 inches to remove air. Since the slurry is prepared in batches two mixing tanks are used so as to provide for continuous operation. A metering pump then feeds this mix to a heater consisting of concentric cylinders, an outer space of which contains the heating medium. The space through which the slurry passes is a narrow annular portion containing rapidly moving blades which remove the mixture from the heated surface and also act as mixers. When starting up, the feed is recycled for a few minutes until equilibrium is established. The mixture leaves the heater after an interval of 10 to 180 seconds, at a temperature of about 300° F. and enters a cooler which is identical with the heater but which employs water in the jacket. The stream leaving the cooler is kept at a predetermined temperature of 110° to 140° F. for delivery to insulated gelling tanks, holding 5500 pounds each. The lubricating grease remains in these tanks from 12 to 20 hours by which time it has assumed a stable gel structure. It is then drawn out by a pump and passed through a worker into packages. Since the initial mix was deaered this operation does not have to be repeated.

The advantages claimed for this continuous process for production of aluminum base lubricating grease are a more uniform product, conservation of space, labor savings and a higher yield per pound of soap. That is, a given consistency is obtained with less soap than by the pan method of cooling.

Barium-Base Lubricating Grease

One of the more recent developments in the lubricating field is the production and marketing of barium-base lubricating greases. Such products are characteristized by extreme resistance to removal from bearings by water, high melting point, good adhesiveness and cohesiveness and resistance to change in consistency due to the working action of bearings. The above characteristics qualify this type as a multi-purpose lubricating grease for automotive and farm equipment. The versatility of this type of lubricant has also led to many industrial applications. Thus one large corporation reports[1] that at three of their plants they employed barium-base grease as a multi-purpose lubricant with satisfactory results during a test period of more than a year.

The high melting point and adhesiveness of this type of lubricant is shown in Figure 5. The illustration is of a hot-plate which is adjustable from 100° F. by 50° increments. This apparatus was inclined at about 45 degrees and samples of barium, lithium, sodium and calcium base lubricating greases placed on the cold plate. When the heat was raised to 200° F. the calcium-base product melted and slipped off. On further increasing the heat the sodium base grease slipped off at 300° F. At this temperature the lithium base product barely moved but slipped readily at 350° F. Since the barium base lubricating grease was still in place, the temperature was raised to 400° F. when, as the photograph shows it still adhered to the plate.

Manufacture of Basic Barium Lubricating Grease

Up to the present barium-base lubricating greases are made only batch-wise. As will be brought out later, the product is not as simple to process as some of the more conventional lubricating greases and therefore there is no immediate prospect of manufacture by a continuous process.

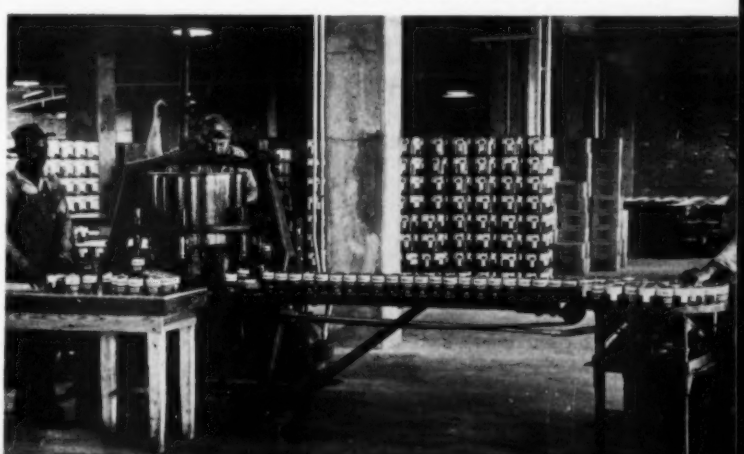
In 1936 a patent[2] was issued to Ott and co-workers calling for the manufacture of a lubricating grease from a basic barium soap. Apparently considerable work was required to perfect both the product and the process, but in 1943 McLennan[3] stated that such a lubricating grease had been marketed for a period of over six years with increasing volume. Soon after this, manufacture of this type of product was also undertaken by another firm and for the past several years several million pounds per year have been marketed.

The basis for the manufacture of basic barium soap is the fact that, under the proper conditions, barium hydroxide will react with normal barium soap to form a complex termed basic soap. This basic soap will in turn disperse in mineral oil to form lubricating greases which are both water and heat resistant.

For the manufacture of lots of 5000 pounds or more the kettle agitators should be powered with not less than 40-hp. motors and preferably with 50-hp. Of course the gearing and agitators should be of sturdy construction and two or more speeds should be provided. A jacketed kettle is preferable so that cooling water as well as steam at not less than 120 pounds pressure can be used.

A batch of this grease is started by charging tallow, an amount of mineral oil equivalent to about one-fifth of the tallow and a weight of barium hydroxide about equal to that of the tallow. The mineral oil is asphaltic or naphthenic in character so that it will have sufficient solvent power to maintain the mass in a plastic workable condition. The barium hydroxide originally used was an octohydrate and consequently approximately one fifth of the original charge was water which had to be removed by evaporation. A pentahydrate is now available so that less water must be evaporated and the heating cycle is thus shortened slightly.

Figure 4—Filling Small Packages of Lubricating Grease.
(Photo courtesy, Sinclair Refining Company)



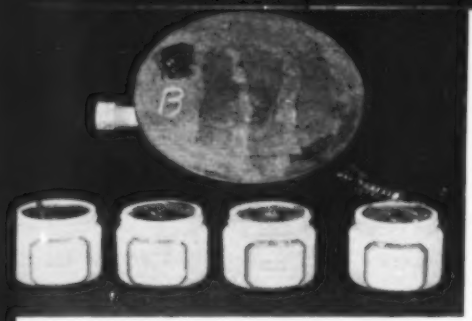


Figure 5 (above)—Hot Plate Test of Types of Lubricating Grease.

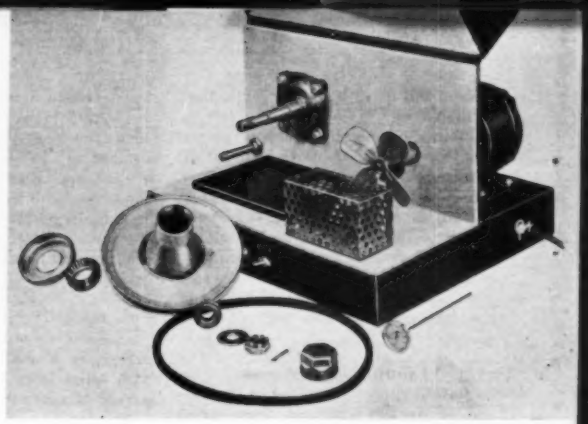


Figure 6 (right)—CRC Wheel Bearing Tester.

Heat and agitation are started and, unless foaming is encountered, continued until most of the water is driven off, which will be when the temperature has reached about 230° F. Up to this point the normal amount of barium hydroxide has combined with the tallow and we have a mixture of normal soap, mineral oil and free barium hydroxide. The reaction which will follow is exothermic, consequently the heat is then shut off and when the temperature of the contents continues to rise, steam is released from the kettle jacket. When the temperature reaches 350° to 375° F. it is checked by addition of further oil or by use of water in the jacket. If the charge reaches a temperature of 400° F. or more some charring may occur.

Up to the time the charge approaches 300° F. the mass is rather soft but it then changes to a dry mixture which forms in large lumps or balls. It may be necessary at this time to shift the agitators into low speed and to watch the ammeter for overload. If necessary, oil can be added to reduce the load. After a period, sometimes of several hours, the mass will assume a dark reddish color and become smooth and viscous.

At this point samples are withdrawn for laboratory titrations. In removing a sample the agitators are stopped but the idle period should be short, otherwise difficulty will be encountered in starting again. The reaction is carried to the point where 0.5 percent of free base remains. Up to this time at least one third of the final oil will have been added. Since the final grease will contain from 0.1 to 0.3 percent of moisture it is necessary to add sufficient water to hydrate the charge at this time. Following this the remainder of the oil is added and the grease is milled to smooth it out. The original manufacturing procedure called for drawing the grease into cooling pans and milling cold, but, by careful temperature control, it has been found possible to finish the grease in the cooking kettle. With most types of lubricating grease the cycle of manufacture is such that batches can be completed in an eight hour shift but so far this has not been possible with charges of basic barium grease.

Complex Barium-Soap Lubricating Greases

In 1947 McLennan was granted a series of patents[4] covering the manufacture of lubricating greases from what he termed "complex soaps" and in this series was that of barium. This type of barium-base lubricating grease has largely superseded the basic type. The basic type is buttery and plastic while the type made from complex soap is fibrous.

Complex barium soap results from reacting normal barium soap with a barium salt made from a relatively low molecular weight fatty acid. While the claims mention a number of barium salts as being suitable for formation of the complex barium soap all of the illustrations given call for the use of barium acetate.

Production of this type of barium lubricating grease requires the same type of equipment as does the basic barium grease—at least 40-hp. motors with sturdy agitators and two or more speeds. Steam pressure high enough to give a temperature of 300° F. or higher is required.

In starting a charge, tallow or tallow fatty acids are added to the kettle together with naphthenic type mineral oil equivalent to half the weight of fat. In a separate wood or stainless steel vessel an amount of acetic acid which will produce barium acetate equivalent to the normal barium tallow fatty acid soap in mol ratio, is mixed with three and one quarter times its weight of barium hydroxide. This mixture, together with another portion of barium hydroxide equal to the above, is added to the kettle. Agitation and heat are started, the temperature being gradually increased until danger of foaming is past. Approximately three hours are required for dehydration. As this point approaches the charge will become very heavy and further oil should be added in order to reduce the load on the drive. After dehydration the temperature is raised to 300° F. for a period of two hours to effect complete reaction. Of course the charge is finally adjusted so that it is almost neutral.

Since a trace of a polar liquid is effective in producing a proper structure in a complex barium base lubricating grease, rehydration of the mixture is now carried on. Even though the final grease is to be substantially anhydrous, improved characteristics can be obtained by the addition of 0.1 to 3.0 percent of water at a temperature below its boiling point and subsequently increasing the temperature to effect substantially complete dehydration. The mass, which at this point should contain twice as much oil as soap, is cooled to 200° F. by introduction of water in the kettle jacket. About one gallon of water is added for each 50 pounds of soap and when this is throughly mixed with the charge, the temperature is increased to 280° F.

The charge is again cooled to 200° F. and additional oil added to bring it to the desired consistency. Improvement in the texture is obtained by working the lubricating grease at temperatures below 200° F. and preferably below 150° F., prior to packaging. For such working gear pumps and screens down to 40 mesh have been found effective.

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[2] Ort, Clark and VanMarter, U. S. Patent 2,033,148.

[3] McLennan, L. W., *Barium Grease*, The Institute Spokesman, Vol. VIII, No. 1, April 1944, p 1, 4-7; No. 2, May 1944, p 2-4.

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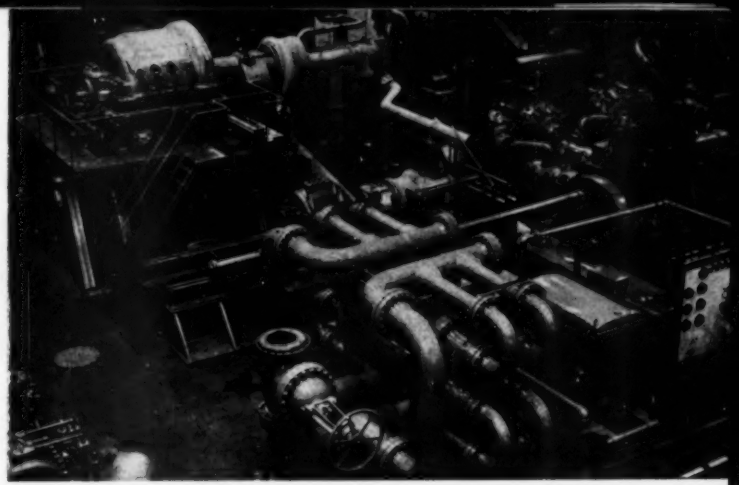
End of Part IV. Part V will appear in an early issue.

Build World's Biggest Centrifugal Compressor

C. C. PRYOR
Associate Editor



Experimental and test set-up for gas turbine and centrifugal compressors in Clark Bros.' plant at Olean. The centrifugal compressor under test is being driven by a gas turbine of the reaction type, which utilizes the power available in the exhaust gas of a special gas generator type of engine (right background). Five of the eight cylinders of the gas-generator engine are gas engine cylinders rated at 200 hp. per cylinder. The other three cylinders are special oil-fired supercharged cylinders; however, all power cylinders are tied into a common crankshaft. Power developed is used to compress air to 60 psig. for combustion air for the three special gas generator cylinders. The gas generator cylinders develop 3½ to 4 times the horsepower of the standard power cylinders and the exhaust gas leaves at approximately 50 psi. and 850 to 900° F. Expanded in the reaction type turbine, it develops about 3000 hp. at about 3900 rpm., which drives the compressor under test.

THE largest installation of centrifugal compressors in the world, 24 units totaling more than 80,000 horsepower, will be made in the first Carthage Hydrocol Inc. process plant for the synthesis of gasoline from natural gas at Brownsville, Texas. Initial tests of parts of the battery of centrifugals were witnessed in May by newspaper and trade press correspondents assembled at the manufacturing plant of Clark Bros. Company, Inc., Olean, N. Y., which designed and built the compressors. One of the compressors will be driven by an air-expansion type turbine. According to F. W. Laverty, general sales manager of the company, the combination of three of the No. 5 compressors is the largest single-shaft centrifugal compressor ever built.

Centrifugal compressors, called "blowers," have been in use in this country for about 25 years. Basically, the centrifugal compressor consists of a number of wheels or impellers mounted on a shaft rotated at high speed. Gas enters the case at the eye of the impeller near the shaft and is thrown out at a high speed by the centrifugal force created by the impeller. The gas is compressed, not by physically decreasing the volume, as with a piston, but by accelerating the gas to a high velocity then slowing it down in the compressor to change the velocity into pressure. Because the compressors operate at high speed, a relatively small compressor can compress a large volume of gas.

A centrifugal compressor requires half the space of a reciprocating compressor of the same capacity and weighs about one-third as much. Thus, first cost of the centrifugal is quite low.

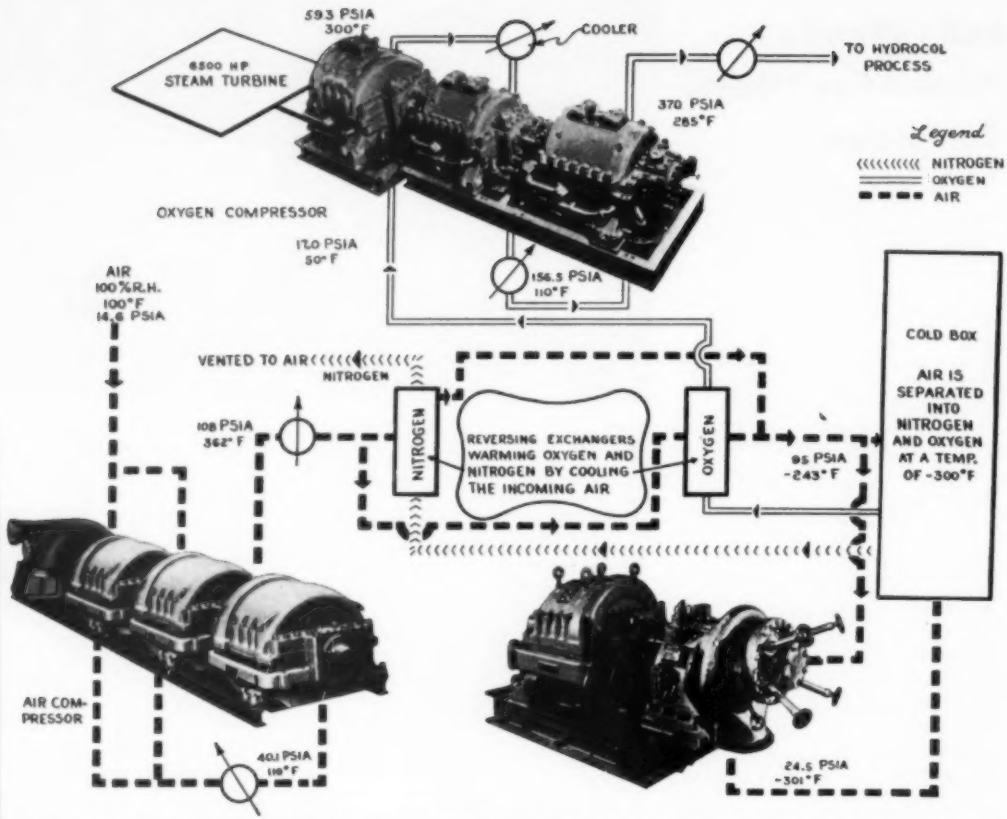
One of the requirements of the Brownville plant was the compression of large volumes of air and gases. Since the process of the plant is exothermic, large amounts of steam are generated by the heat liberated from the reactions of the basic gases. The most logical use of the steam was in steam turbines to drive the centrifugal compressors.

At Brownsville, the centrifugal compressors will compress six different gases, ranging from air to pure oxygen. The two main air compressors in the plant compress 110,000 cubic feet per minute to 108 psi and have a power requirement of 23,000 horsepower each—46,000 horsepower. The steam turbines require 125 tons per hour of steam. The compressors supply air for two plants producing 2000 tons per day of pure oxygen for use in the process.

According to Clark Bros., a single air compressor unit in one minute compresses the volume of air that would be enclosed in a pipe 12 inches in diameter and 27 miles in length. The oxygen compressor units used in the Hydrocol plant develop a total compression ratio of approximately 23.1 with a single drive. Among the safety precautions incorporated in the design of the oxygen compressor is prevention of contact of the oxygen and oil. Also, the internal parts of the compressor are made of special bronze alloy and water-cooled to maintain safe internal temperature, and incidentally to improve the over-all efficiency of the compressor.

Clark Bros. began design and development of a line of multistage centrifugal compressors in 1944—involving a series of five different standard sizes. The compressors were designed for coupling in tandem for drive-through operation. Other features included water cooling of the machines and use of a special bronze

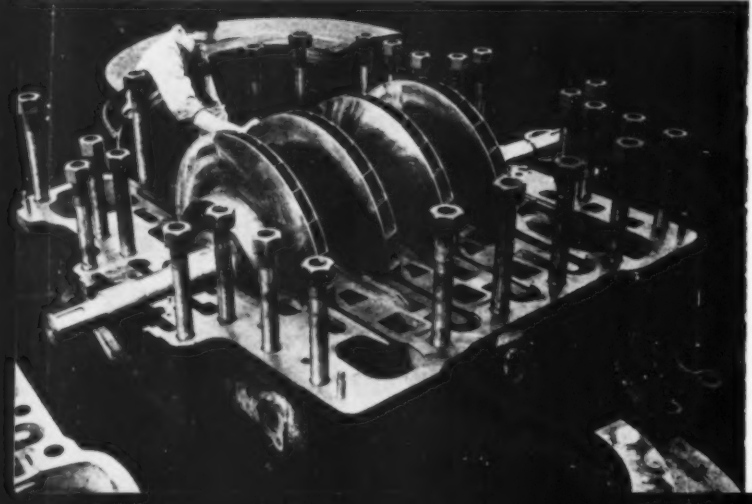
The Olean, N. Y., plant of Clark Bros. Company, Inc., which has been expanded during the past ten years, eight of which it has been one of the Dresser Industries, Inc. Its facilities are capable of producing upwards of 60,000 bhp. per month of gas engine, electric, and diesel driven reciprocating compressors, centrifugal compressors of both axial and radial types and gas and diesel engines. View here is heavy machine section of main machine shop.



Simplified flow chart of the Carthage Hydrocol Oxygen plant. There are three four-stage centrifugal cases in the main air compressor (pictured at lower left), the first two cases operating in parallel to boost pressure from atmospheric to 40.1 psia. to the third case, which discharges at 108 psia. Oxygen is compressed in a three-stage centrifugal compressor (pictured at top center), 6200 bhp., from 17 psia. to 370 psia. The unit is driven by a steam turbine delivering 6500 hp. Refrigeration for cooling and partially liquefying the air is obtained by cold air at 95 psia. and —243° F. expanded in an expansion turbine, shown above at lower right.

diaphragm to obtain an exceptionally high rate of cooling. Besides the multi-stage compressors, the company has developed a line of single-stage pedestal type centrifugal compressors and radial expansion turbines. In 1947, the first group of centrifugal compressor units were completed for compressing air from atmospheric pressure to 125 psia and involved a total of 12,750 horsepower.

C. Paul Clark, president of Clark Bros. said the primary purpose of the test installation is to ascertain the feasibility of gas turbines with high output and high efficiency as prime movers for long distance transmission of natural gas. Gas turbines have been built in large sizes, he said, but until recently their efficiency has been too low to make them attractive for commercial projects. The new designs of gas turbines permit smaller foundations and buildings with subsequent savings in installed cost per horsepower, and offer future potentialities of greater fuel savings. Gas turbines, he added, since they do not require water in their operation, should be particularly useful for desert installations.



At left—Assembling a No. 5 four-stage centrifugal compressor which has an approximate maximum of 60,000 cubic feet per minute at a normal speed of 4150 rpm., intake pressure of 60 psig. and discharge pressure of 110 psig. Maximum shaft horsepower is 22,000.

THERE IS a significant trend in process plant instrumentation toward the more general use of analysis type instruments for the direct control of operating variables. Just as in the past the development of satisfactory instrumentation for the automatic control of the physical variables — temperature, pressure, flow, liquid level, and so on—resulted in great improvement in process plant operation, so now will instruments capable of analyzing process stream compositions bring about smoother operation of process equipment and a higher percentage of "on-specification" production.

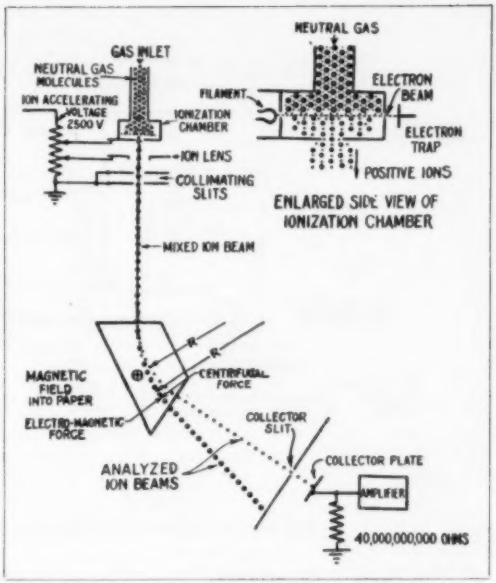


FIGURE 1
Schematic diagram showing principle of mass spectrometer.

Analytical Instruments In Automatic Control Systems

NELSON GILDERSLEEVE
Special Products Division, General Electric Co., Schenectady, N. Y.

THE newer analytical instruments, especially recording types, are to be found today in actual process applications and a few of them are even now faithful process controllers.

Many who walk through the laboratories of chemical, petroleum or rubber plants and see photometers, spectrophotometers, spectrometers, refractometers, colorimeters, titrimeters, polarographs and analyzers of many types may think that the process industries are already flooded with analytical instruments. How many of these instruments have escaped from the Ph. D. in an air-conditioned laboratory to the humid, corrosive atmosphere of a process where a hose cleans the walls, floors and the instruments?

Process control is generally defined as the measurement and control of non-electrical variables; some of the variables being temperature, pressure, fluidflow and liquid level—the measurements upon which most processing for years has been based. Add to these variables conductivity, pH, humidity, speed, time and vacuum and you have a list of the important measurable (and hence *controllable*) processing conditions.

A process which is held at predetermined settings of processing conditions generally produces a satisfactory product. However, the purchaser of any material buys it only if it has the proper properties, as determined by acceptance tests, for the materials' end use, such as color, corrosion resistance, proof, viscosity, dielectric strength, etc., all related to product *quality*. If these properties can be measured continuously as a process goes on, then we can measure *what is being done*, rather than the old-fashioned method of measuring on a sampling basis *what has been done* at some spot remote from the process sometime after conclusion of the processing of a batch of material.

Here is a list of some *measurable* properties of materials:

Analysis or composition
Color
Consistency
Density or specific gravity
Dielectric strength
Heat of combustion
Mass or molecular weight
Moisture content
Refractive index
Turbidity
Viscosity

Of these properties analysis, calorific value, mass weight, and moisture content (generally), or their interpreted data, will primarily be considered chemical properties, and all the rest, physical properties.

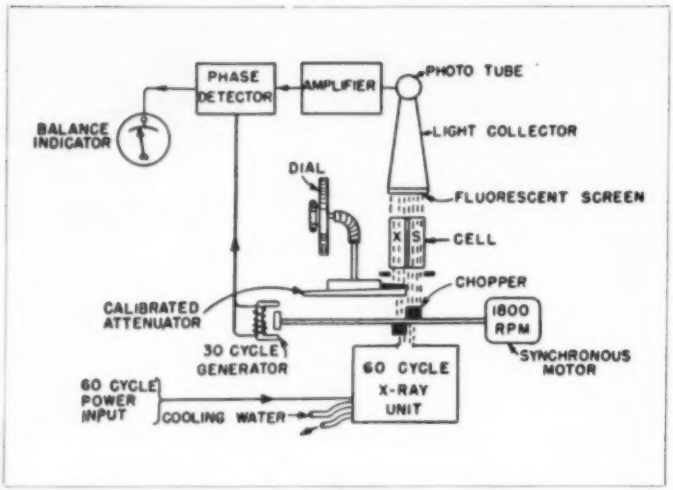


FIGURE 2
Diagram Showing Arrangement of X-Ray Photometer

Analytical instruments may for convenience be combined in four groups, based both on the type of information available from the instrument and its breadth of application:

1) The mass spectrometer, the master analyst used for gases or liquids vaporized at high vacuum. It alone will perform both qualitative and quantitative analyses in the broadest est sense of the term on all materials that can be introduced into the spectrometer. The interpretation of measurement is obviously of a chemical nature.

2) Absorption spectroscopy instruments—x-ray, ultra-violet, visible, and infrared. These instruments are all applied to liquids and gases, and sometimes to solids. They are used for qualitative analysis by comparing the absorption spectrum of an unknown substance with the spectra of known substances which additively will give the unknown spectrum. They are widely used for quantitative analysis. Their advantage when used as spectrophotometers is in the multitude of peaks and valleys which gives an incontestable identity to each compound. The absolute value of the measured quantity is based upon the chemical composition and configuration of the structure of the substance, so that the measurement is essentially of a chemical property.

3) Instruments for physical properties measurement which are generally most applicable to two or three component systems and normally used only for quantitative analysis.

The physical property measured is the sum of the individual measurements of the particular property of each component. A variation in the total measurement can, of course, be caused by any one of the components. If, however, the process is instrumented well and the best physical property used for analysis, a variation should be caused only by the preselected critical component whose normal value is quite different from the value of the other components. It is often said that these instruments are only good until an unknown impurity is introduced.

These measurements are not inferential in the sense of the use of processing conditions measurements as the determinant of chemical or physical properties, and thus a measure of product quality. There will always be a known predetermined relationship between the physical property and analysis, so that an absolute measurement of a physical property with the components of the material *known qualitatively* will indicate one and only one quantitative analysis for the material. Thus the term "analyzer" as used by many instrument manufacturers in referring to devices which measure physical properties is correct only on a limited basis which takes into account all the predetermined information required.

Some of the physical properties are a) heat of combustion—The oxidation of hydrocarbons and combustible gases in combustion produces a measurable temperature rise which is a function of the heat of combustion of the gas; b) refractive index—The refraction of light is a function of the composition of a fluid; c) thermal conductivity—The ability of gases to conduct heat from a hot wire may be used in analysis and d) dielectric constant—The dielectric properties of a material are often a function of the composition of the material.

4) The fourth group includes devices specific to a single element or compound such as water vapor, carbon monoxide, or oxygen. These devices can analyze for only one compound because of the basic principle of operation or because of limited design for a single compound. They may measure chemical or physical properties of materials.

a) Chemical combined with optical —Certain chemical reactions cause color changes which are a function of a compound's concentration; such color changes can be measured optically.

b) Conductivity—Solution conductivity is sometimes a measurement of concentration. Conductivity measurement preceded by chemical reaction offers a means of analysis.

c) Hydroscopy—absorption of moisture by salt is specific to moisture.

d) Magnetic susceptibility — Oxygen and a few rare gases have a relatively high permeability to a magnetic field.

Group 1

The analytical mass spectrometer can be employed in process control by analyzing samples brought to it, accepting the long analysis time as a process lag, and using the results for control. A mass spectrometer (Figure 1) separates gas molecules within a high vacuum according to their mass by ionizing the gas, accelerating the ions, and deflecting them in a magnetic field. By variation of the ion accelerating potential, or by variation of the magnetic field, ions of different specific mass can, in turn, be focused at the collector slit, giving a mass spectrum for the gas sample as the magnetic field is swept across a wide mass range. The mass spectrum is actually a spectrum of collector plate currents at each mass. The current is proportional to the number of ions striking it and therefore represents mass concentration.

A mass spectrometer is now available which will record up to eight mass concentrations almost continuously. Known as the "process control spectrometer," it has a continuous sample feed with a transportation lag within the instrument of less than a second. A multipoint recorder programs the ion accelerating voltage so that in turn eight different mass con-

centrations are continually recorded. Any mass up to 80 can be recorded, though the spectrometer will only resolve completely up to mass 44, and the various peaks to be recorded must appear within a 6-to-1 mass range. Because a fixed magnetic field and variable accelerating voltage is used, the top mass number as well as the range are limited.

As a controller, the spectrometer can record a single mass continuously and use standard pneumatic or electrical control from the recording instrument. One specific application involves the recording of 0.2 percent propylene, 5 percent methane, and 5 percent ethane in an ethylene stream. In some cases a wide slit might be used with several mass concentrations recorded simultaneously, giving, for example, the total C_4 concentration in C_3 and lighter hydrocarbons.

As a recorder only, the Process Control Spectrometer has been very useful as a trace detector, particularly where low concentrations of several gases are involved.

Group 2

Absorption spectroscopy in analytical instrumentation involves x-rays, ultraviolet, visible, and infrared waves. Somewhere in the electromagnetic spectrum practically all substances possess a selective absorption which can be used as a positive identification, even in the presence of many other materials. Emitted light anywhere in the electromagnetic spectrum is characteristic of the atom or molecule producing it. Any material will absorb the same frequencies it would emit if it were heated to incandescence. If the wavelength of the light passing through a material varies, the received light that has passed through the material when measured and recorded forms a spectrum of transmission, generally characterized by a series of peaks and valleys.

X-ray

The G.E. x-ray photometer is a *photometer* in the true sense of a photometer's comparing two beams of light and reducing them by one means or another to equal intensities. By whatever law is used in the reduction, a determination is made of the original intensity of the "test" beam and therefore of the analysis of the absorbing medium. Thus a photometer is generally used only for quantitative analysis.

Absorption in the x-ray spectrum is an atomic property, so that analysis is completely independent of the physical or chemical state of the element; a chlorine atom, for example, will show the same absorption in chlorine gas, hydrochloric acid, or table salt. The higher the atomic number, the greater is the absorption for a given mass. Therefore the sensitivity of this method of analysis may vary from 0.01 percent to 1.00 percent by weight of component concentration, depending upon the difference in atomic numbers of the elements involved.

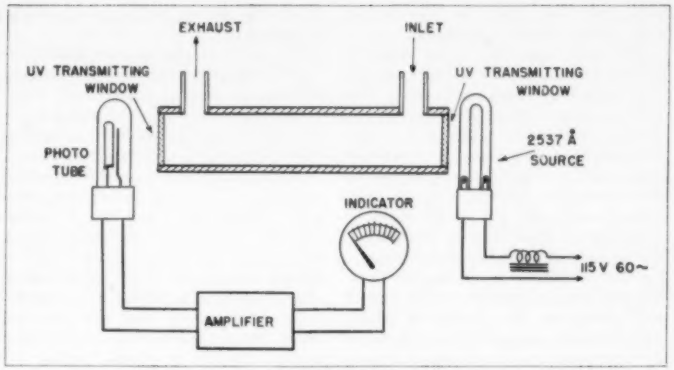


FIGURE 3
Diagram Showing Principle Operation of Mercury-Vapor Instantaneous-Type Detector

Some typical applications are 1) 0 to 10 cc. of tetraethyl lead per gallon of gasoline can be determined with an accuracy of ± 0.03 cc. per gallon; 2) 0 to 5 percent sulphur in oil can be determined with an accuracy of ± 0.05 percent; and 3) 0 to 10 percent chlorine in plastics can be determined with an accuracy of ± 0.5 percent.

A broad-band spectrum of x-rays (0.35 to 1.07 angstroms) is emitted from the tungsten-target tube (Figure 2). The 60-cycle voltage on the tube produces x-rays 60 times per second during the positive half-cycles. A two-bladed chopper, rotated by a synchronous motor, is so placed that it alternately interrupts the two halves of the x-ray beam which pass through the sample and through the standard.

The x-rays pass through the cells to a fluorescent screen where they are converted to a blue-green light which passes through the light tunnel to the multiplier-type phototube. The phototube electrical output is amplified and fed into the phase detector. The chopper motor carries on its shaft a 30-cycle generator whose output is likewise fed to the phase detector. The detector converts the inputs from the phototube and generator to a direct current whose magnitude and polarity depend upon the relative intensities of x-rays transmitted through the reference and the sample.

A wedge-shaped calibrated variable aluminum attenuator in the sample beam is used to balance any difference in absorption between the two beams. When the beam intensities are equal, a zero reading is obtained on the balance indicator. From the attenuator dial reading, having a previously made calibration, the concentration of the absorbing element can be determined. The attenuator dial can be calibrated in mils of aluminum or directly in terms of the concentration of material being measured. The attenuator may be motor-driven to balance, and its position recorded, thus allowing continuous recording of a compound's concentration in a process stream, and therefore making possible continuous control.

Ultraviolet

Because of the ready availability of mercury light sources and phototubes responsive to 2537 Angstrom radiation, the main mercury line, absorption

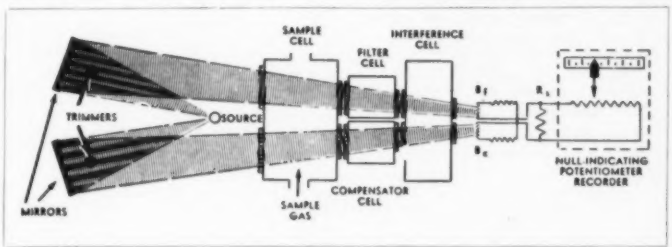


FIGURE 4
Optical Diagram of Four-Cell Control Element for Baird Associates Recording Infrared Gas Analyzer

work has been done in this region with rather simple instruments.

The G.E. mercury vapor detector (Figure 3) is probably the simplest ultraviolet instrument for analysis. The test gas passes through a cylindrical chamber within the instrument, at opposite ends of which are an ultraviolet lamp and a phototube responsive to 2537 radiation. If the detector is calibrated with pure air in the chamber and mercury vapor is then introduced, the amount of ultraviolet light reaching the phototube is decreased, causing a change in the phototube output and unbalance of a bridge of which the phototube is a part. This unbalance is registered on an indicating instrument as mercury concentration. The toxic limit of 1 milligram of mercury per 10 cubic meters of air appears at 10 percent of full scale reading on the indicating instrument.

The Beckman recording photoelectric spectrophotometer is a modification of the Beckman quartz spectrophotometer which makes possible continuous automatic analysis of liquids or gases. As ordinarily furnished, the instrument measures continuously the percent light transmission of a sample using monochromatic light at any fixed wavelength between 220 and 360 millimicrons, by use of a monochromator in the near-visible region of the ultra-violet where hydrocarbon analysis is best; with a different light source and phototube, the spectrophotometer may be used up to 1000 millimicrons. Thus the instrument has the sound engineering practice of having a broad range of application which can easily be set for determination of a specific compound.

Percent transmission from 0-100 percent of the sample is recorded directly with an accuracy of ± 1 percent. Automatic repetitive standardization by a 100 percent transmission compensating reset circuit to compensate for changes in light output of the lamp, phototube sensitivity, or transmission characteristics of the absorption cell, is a feature of the device. Every five minutes a transparent reference gas or liquid is passed through the spectrophotometer. The phototube amplifier is automatically adjusted so that the recorder reads 100 percent transmission. Thirty seconds each side of this period are devoted to purging; thus a record of percent sample transmission is drawn for $3\frac{1}{2}$ out of 5 minutes.

Infrared

An infrared spectrophotometer is undoubtedly second to the mass spectrometer in its ability to render both quantitative and qualitative analysis, particularly for organic compounds. At the present time the impetus toward use of an infrared analyzer on a process line seems greater than with any other instrument in the electromagnetic spectrum. The wavelength region of the infrared spectrum used for commercial instruments is 2.5 to 25 microns.

The application of infrared to distillation columns is accelerating, for the output of these columns generally consists of a few components of about the same molecular weight, making infrared most applicable because the small number of components may not have overlapping spectra, and because mass spectrometers are most sensitive where molecular weights are separated.

Baird Associates have an automatic recording infrared analyzer for continuous analysis. As a photometer the instrument has a higher level of energy passing through the sample than the spectrophotometer, yet has sensitivity to a single compound through judicious selection of filters. Two balanced infrared beams (Figure 4) from a single source pass through a cell system onto two bolometers which are part of a bridge circuit feeding a potentiometric recorder.

In operation, a stream of dry gas at constant pressure is passed through the sample cell covering both beams. Thus infrared energy in any but the desired absorption band affects both bolometers equally and causes no unbalance of the bridge circuit. The filter cell is filled with a pure form of the gaseous component whose concentration in the sample gas is to be recorded or controlled. Because of the relatively high filter cell concentration, all of the energy at the characteristic absorption wavelengths for the gas in the filter cell is removed from the infrared beam passing through this cell. Hence variations in the concentration of the component of interest affect only one bolometer. The resultant differential in energy reaching the bolometer, and therefore bridge unbalanced, is a function of the concentration of the measured component in the sample gas mixture.

When the gas mixture contains components whose absorption bands overlap those of the gas for which analysis is to be made, an additional cell which contains large quantities of the components likely to interfere with analysis is employed across both infrared beams; this is the interference cell. Thus the final instrument output will be solely due to the component of interest. So that the output of voltage unbalance versus component concentration may be as linear as possible, a compensator cell with about 10 percent concentration of the maximum component concentration expected is used. It decreases the instrument sensitivity, but spreads the range, keeping it fairly linear.

Because the instrument must operate for long periods without "drift," automatic standardization is performed similarly to that of the Beckman ultraviolet analyzer. Such standardization is generally necessary where two receivers are used. This is opposed to instruments such as the x-ray photometer in which the beams are brought to balance or equivalence so that standardization is not necessary.

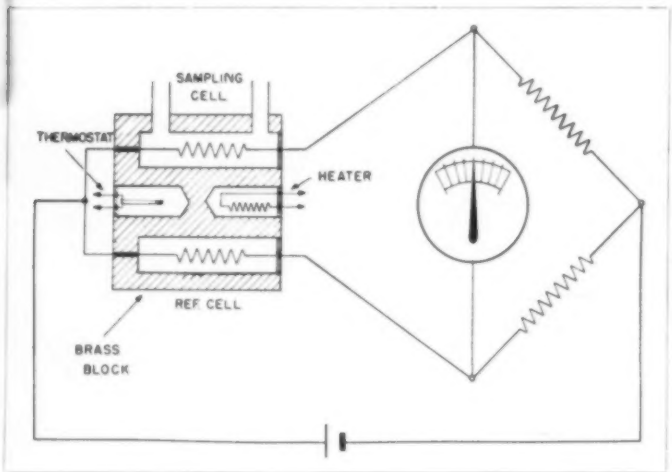


FIGURE 5
Diagram Showing Principle of Operation of G-E Thermal Conductivity Gas Analyzer (Thermostated)

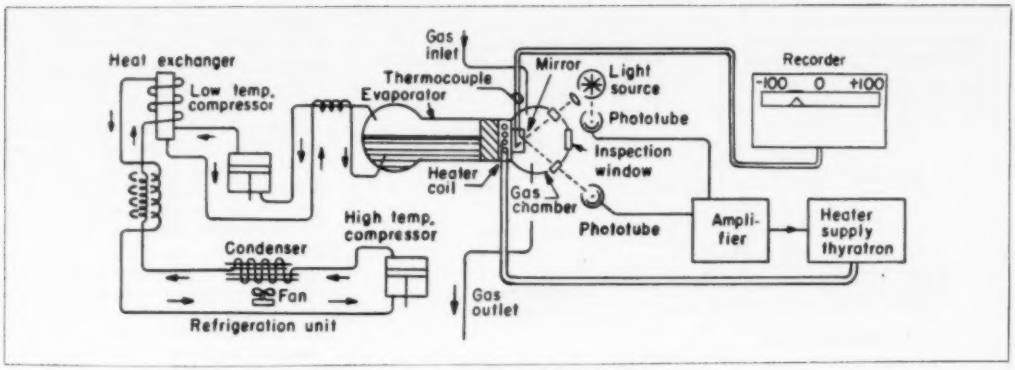


FIGURE 6
Sketch Showing Operating Principle of a Dewpoint Recorder

Group 3

Consider now analytical methods which involve measurement of physical properties of materials such as acoustical frequency, heat of combustion, density, and thermal conductivity. These measurements are single over-all measurements with no point of selectivity as found with absorption spectroscopy. These methods are of course best when one component has a measurable physical characteristic widely different from those of the other components.

Thermal-conductivity

Thermal-conductivity is one of the oldest analytical methods. It is used widely in hydrogen purity measurement, flue and stack gas analysis, and furnace atmosphere work. A polished wire (Figure 5), which is placed axially within a polished metal tube, will have 98 percent or more of the heat loss caused by current in the wire removed by conduction. With a constant rate of energy supplied to the wire, the temperature which the wire assumes will vary inversely with the thermal-conductivity of the gas surrounding the wire. The wire temperature, determined from a resistance bridge, is a measure of the composition of the gas mixture. The thermal-conductivity of the mixture to be analyzed is compared with that of a known gas composition called a "standard" or "reference" gas in the resistance bridge.

Hot-wire for Heat of Combustion

The hot-wire method of analysis is identical circuit-wise to thermal-conductivity. In thermal - conductivity, the filament is operated below 400° F. to avoid catalytic combustion. With the hot-wire, catalytic combustion is desired and the bridge is operated with platinum filaments at red heat. Unbalance of the bridge is caused by combustion which changes the filament resistance by heating the filament.

With an excess of air or oxygen combining with a sample gas, the hot-wire method will measure total combustibles, including gases such as hydrogen, carbon monoxide, and hydrocarbons, singly or combined. If an oxygen-laden gas is burned with an excess of a synthetic fuel, then oxygen concentration can be recorded. With either system, the minimum reasonable full scale recording range is about 0-5 percent with an accuracy of ¼ percent of gas concentration.

Group 4

The specials include instruments applicable to only one or a few compounds. Here is found real variety in physical principles, and combinations of simple, common phenomena engineered into useful, sensitive instruments.

Water Vapor

The G.E. dew-point recorder is based upon the well-known dew-point principle that the temperature of a surface on which moisture will just condense from a gas is its dew-point temperature, which is directly a function of the absolute humidity of the gas. The temperature instrument records the actual mirror surface temperature by a thermocouple whose output is calibrated from +100 to —100° F.

Gas in measured flow passes through the gas chamber (Figure 6) and over the mirror surface. Cooling the mirror is a 2-stage refrigerator which operates continuously to keep the mirror at a very low temperature. Behind the mirror is a heater coil to raise the mirror temperature above the minimum held by the refrigerator.

A light source passes light into the gas chamber where it is reflected from the mirror surface to a phototube. The operation of the instrument is such that as dew forms on the mirror, its reflectivity is reduced; with less light reaching the phototube, its output is decreased. This change in phototube response is amplified and increases the output of a thyratron tube to the heater. Raising the temperature of the mirror evaporates the dew from the surface, causing the reflectivity of the mirror and thus the phototube current to increase. This response results in less output from the thyratron, a cooling of the mirror surface, and eventual precipitation of dew. The system will slowly cycle between dew and no dew with a maximum cycle amplitude of 2° F. The second phototube is used in a balanced circuit to compensate for changes in light intensity due to line voltage fluctuations, and for tube drift.

Oxygen

The Hays Corporation has developed for oxygen analysis a magno - therm oxygen analyzer which is specific almost only to oxygen. Except for the oxides of nitrogen, oxygen is the only gas that is paramagnetic, or able to pass magnetic flux more easily than a vacuum. Oxygen permeability in itself is very low, but sufficient to permit analysis by the magnetic method.

Basically two thermal-conductivity cells (Figure 7) are used, with the oxygen-laden gas diffusing into both cells. An inhomogeneous magnetic field is placed across one cell by a permanent magnet. Oxygen is attracted to the center of the cell along the hot-wire where the heating causes it to lose its magnetic properties in proportion to the square of the absolute temperature. Since the heated oxygen is no longer magnetic, it is forced out of the magnetic field by the cooler, more magnetic oxygen. The oxygen that is forced out of the field cools itself on

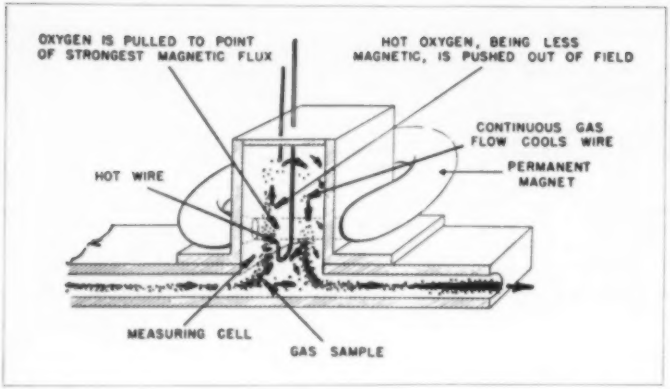

OXYGEN IS PULLED TO POINT OF STRONGEST MAGNETIC FLUX
HOT OXYGEN, BEING LESS MAGNETIC, IS PUSHED OUT OF FIELD
CONTINUOUS GAS FLOW COOLS WIRE
PERMANENT MAGNET
HOT WIRE
MEASURING CELL
GAS SAMPLE

FIGURE 7
Schematic Operation of Analyzing Cell

the cell walls and recirculates. The amount of recirculation is a function of the concentration of oxygen, measured by the amount of cooling of the filament. An automatic compensator in the circuit provides for changes in the gas sample pressure.

Turbidity

Many who hear of turbidity think of muddy water rather than of a quantity determination of some material solution. For instance, the determination of parts per million of barium sulphate in a saturated brine solution is a logical subject for turbidity measurement. A simple and accurate turbidimeter might consist of a light source, cell for the flowing fluid, and a phototube opposite the light source. At right angles to both the light source and phototube is another phototube which measures the amount of scattered light. The relative amounts of light reaching the two phototubes are measured as a ratio which is a function of the actual turbidity. This ratio is impressed on a recorder which gives a continuous record of solution turbidity sometimes interpreted as concentration of precipitates. The instrument is normally sensitive to ten parts per million on the silica scale.

Instruments Desired

What analytical instruments are missing from this review? What would we like to have which is not now available commercially?

In the electromagnetic spectrum the spectral absorption curve of any compound is normally a series of peaks and valleys. With such a configuration, a narrow band light source which can be focused at a wave length corresponding to a peak or valley separated from the absorption peaks of contaminants or other compounds present is desirable and useful. A narrow band thus gives selectivity.

In the x-ray, visible, and microwave regions, there is need for instrumentation. In the x-ray region, an adjustable wave-length monochromatic source that can be set on absorption fringes or discontinuities gives a means of quantitative analysis. In the visible region, even with a recording spectrophotometer as a pattern, instrument manufacturers have not yet built for general sale a selective instrument for either transmission or reflection measurements, either measuring a quantity continuously as an absolute value or in comparison with a reference standard. So little work has been done in the microwave region that little more is possible except indicate the existence of this region for analysis. The fact is that some day this region may be found as useful as infrared.

The value of Raman spectra is not well known because instruments have been lacking. In Raman spectroscopy a beam of monochromatic exciting light passes through a transparent medium in which some of the light is absorbed and may be reemitted. If the reemitted light is examined by means of a spectrograph, very weak spectral lines or bands will appear on either side of the characteristic line of the exciting light. These weak lines which are called Raman lines are characteristic of the substance illuminated. The frequency differences between the exciting light and the Raman lines are independent of the frequency of the exciting light. A qualitative analysis of a mixture may be made by determining the frequency (wave number shifts) of the various lines in a Raman spectrum and comparing these data with those obtained from pure compounds. Quantitative analysis is made by determining the ratios of the intensities of the Raman lines of a substance in the spectrum of the mixture with those of the same lines in the spectrum of the pure compound.

Rather than to try to state definitely the field of application of the Raman spectra, suffice it to say that in general it is complementary to both ultraviolet and infrared, and that sufficient work has not yet been done to allow its field to be defined.

A discussion of refractive index and dielectric constant measurements together may be initiated in that they are both probably considered as a means of measurement when the components of a solution are few, and when the measurement is concerned with purity of a rather high degree. A refractometer should, of course, have a continuous flow of fluid through it, temperature controlled because of the considerable variation of refractive index with temperature, and should automatically record refractive index and therefore concentration. A few such instruments in industry today have been custombuilt by users.

An advantage of dielectric constant over refractive index measurements is that the fluid need not be clear, and it may carry entrained solids. Thus we can think of fluids a little bit dirtier and a little less refined than for refractive index measurement. Perhaps the fluid will run through electrodes, or perhaps a coil will be immersed in the fluid. Both methods are subject to conjecture.

Other Means of Analysis

There are undoubtedly other properties of materials that can be used as means of analysis. Both the sonic and ultrasonic speeds of vibrations passing through a material may be a function of molecular weight or some other property of a material. As other characteristics are considered, however, it is reasonably certain that one will head more and more toward measurements which are not selective to specific components whose concentrations must be determined.

Every instrument manufacturer today is flooded with inquiries on analytical instruments, for apparently all the problems that have ever existed have been resurrected. Recently the chemist of the G.E. phenol plant at Pittsfield reviewed the analysis at every point in the process that his laboratory found necessary to make, and then asked what instruments could supplant each chemical procedure. This *is* an era of analysis.

Fortunately there are only a few who ask for general rules of procedure

in analytical instrumentation to determine what instrument should first be tried as the solution to analytical problems in general. By complete neglect of the dollar sign, it is safe to make a few general statements about the instruments that can be thought of as the matters of analysis.

If a material can be introduced into and removed from a mass spectrometer tube satisfactorily, then the mass spectrometer has the widest opportunity for doing qualitative and quantitative analysis. Within the electromagnetic spectrum we know that x-ray can be used only when an atomic absorption measurement will be satisfactory. The visible range is not now very useful because color is not a sufficient criteria of analysis in the preponderant part of process industry. Perhaps the best delineation for infrared and ultraviolet is to say that in order to keep a list small, one generally says what infrared will not do in organic analysis, and in the same way says what ultraviolet will do in organic analysis. Furthermore, more components can normally be segregated in infrared than in ultraviolet because of sharper peaks and valleys.

Coordinated Control System

The first analytical instruments supplied to continuous processes were generally recording, with no automatic control function, since it was not felt wise to entrust the control of process to instruments not yet tested for stability under process conditions. When the step of making analytical instruments controlling was later made, it was natural to use these analytical instruments in conjunction with already existing controllers. Such a combination gives us a coordinated or interconnected control system.

When automatic control is considered and it is realized that there is deviation in processing conditions or property measurement in a control system, one should recognize that the deviation can be corrected only by a change in material or energy input to the process, or the time of processing or pressure under which processing occurs. Since these are all processing conditions which must be controlled, a processing conditions controller normally actuates a final control element directly for control of one of these functions.

As soon as a physical property is to be measured, the control output desirable from a properties controller must be examined. Before thinking of controller output, however, it must be realized that the physical measurement of a property, which is to be interpreted as chemical analysis, is

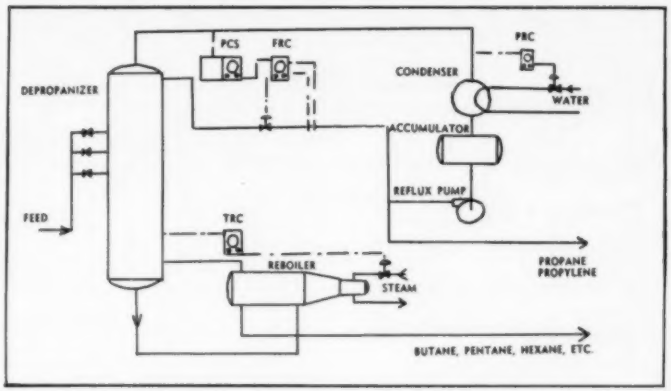


FIGURE 8
Process Control Spectrometer for Distillation Column

necessary after a chemical change has occurred in the materials originally introduced into the process. In chemical engineering such a chemical change is known as a "unit process." When a physical property is being measured as the result of a physical change in materials introduced into a process, it is called a "unit operation." For example, some unit processes are combustion, oxidation, electrolysis, nitration, halogenation, hydrogenation, etc., whereas some unit operations are heat transfer, evaporation, drying, filtration, crystallization, centrifugation, etc.

As a general statement, it is fair to assume that when a physical measurement is made which is a measure of the degree of completion of a unit operation, that in general the physical measurement is made, for use of the data directly; only one or two processing conditions will affect the outcome of the process. Thus, a physical measurement may directly control a final control element which will control a processing condition.

A unit process is normally not reversible because a chemical change has taken place. When the process is continuous there is a steady feed and output of processed material, with varying transportation times through the process. Because of the inherent irreversibility of the process, all processing conditions likely to be variable in nature are normally controlled with the properties controller on the outfeed line resetting one or more of the processing conditions controllers when

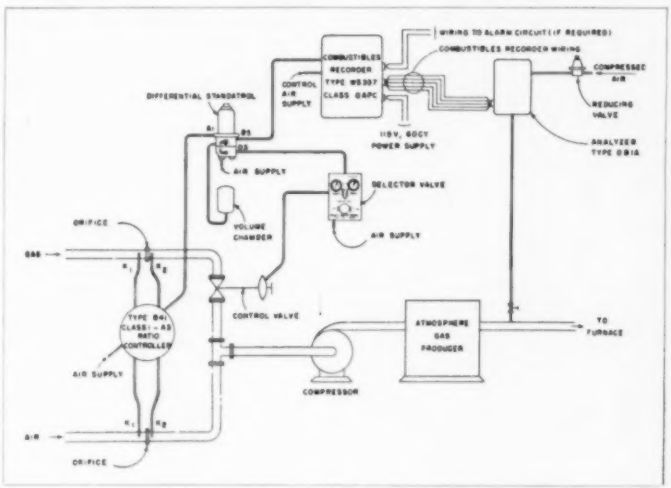


FIGURE 9
Diagrammatic Layout Showing Control for Atmosphere-Gas Producers

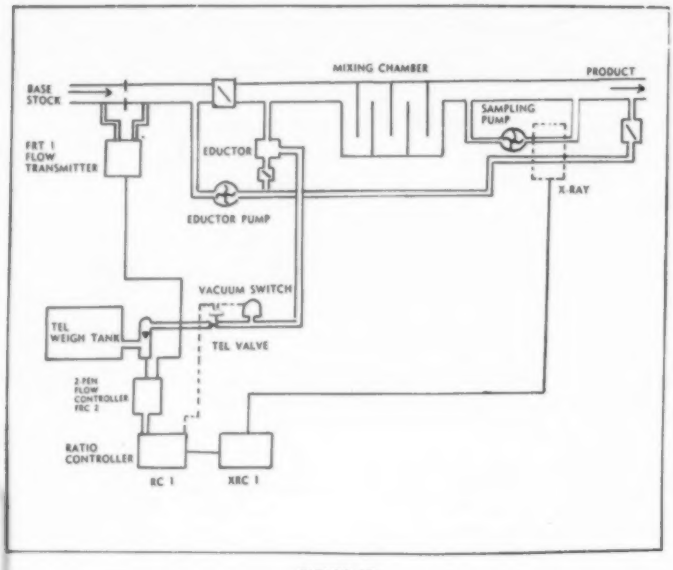


FIGURE 10
X-Ray System for Automatic Blending of Tetraethyl Lead With Gasoline

there is a deviation from product quality. This so-called vernier control enables the interconnected control system to be fast in action and reduces lags appreciably. This is the type of control which we want to illustrate in the examples which follow. It is this control which is the newest in automatic or process controls, but the one, based upon present activity, which should grow fastest in the next few years.

Figure 8 shows a depropanizing tower in which it is desired to hold the percentage of butane and butenes in a propane stream from the top of the tower to a maximum of 3 percent. This was originally accomplished by maintaining a reflux ratio at the top of the tower well over the required amount, to take care of any contingencies, and using a temperature control at the bottom of the tower to adjust steam flow to the reboiler as variations in the feed rate at the tower input occurred which affected the temperature pattern of the distillation tower. The introduction of a process control spectrometer to reset the control point of the flow controller on the reflux line for optimum reflux ratio provides the advantages of greater throughput, since only the minimum amount would now be refluxed, eliminates spoiled products, and reduces laboratory analysis expense.

Figure 9 shows the diagrammatic layout of a control for an atmosphere-gas producer. Gas and air in a controlled ratio are fed into a compressor and an atmosphere gas producer where most of the gas is burned and oxidized to CO_2 before introduction into the furnace, giving an almost neutral atmosphere. A flow-ratio controller is theoretically satisfactory because it regulates gas flow in a fixed ratio to air flow.

The ratio control, however, does not take into account changes in gas analysis or gas pressure, and both of these will affect the composition of the atmosphere gas producer feeding the furnace. Thus a combustibles analyzer is used which takes a continuous sample from the output of the gas producer and introduces a control action into the pneumatic relay which will readjust the gas flow control valve to tibles in the output gas from the gas producer. In this particular set-up the maintain a fixed percentage of combus- combustibles controller can affect the controlled air output from the pneumatic relay equally as much as the ratio controller, but because the pressure and composition variations in the input gas are not usually great, it acts as a vernier control.

The advantage of the system over the use of a combustibles controller without flow ratio controller is that the ratio-control is faster than the combustibles controller in defecting changes in input flow ratio; thus there is less upset to the system.

The continuous automatic blending of tetraethyl lead (tel.) with gasoline can be accomplished basically by a flow ratio control (Figure 10) which adjusts the flow of tel. based upon the rate of flow of base stock which must be leaded. Such a control will maintain accurate proportioning over limited ranges of flow, but where an extremely wide range of flow is experienced, as it may well be in a blending station, simple ratio control based up flow measurement of the two liquids being blended is not sufficiently accurate.

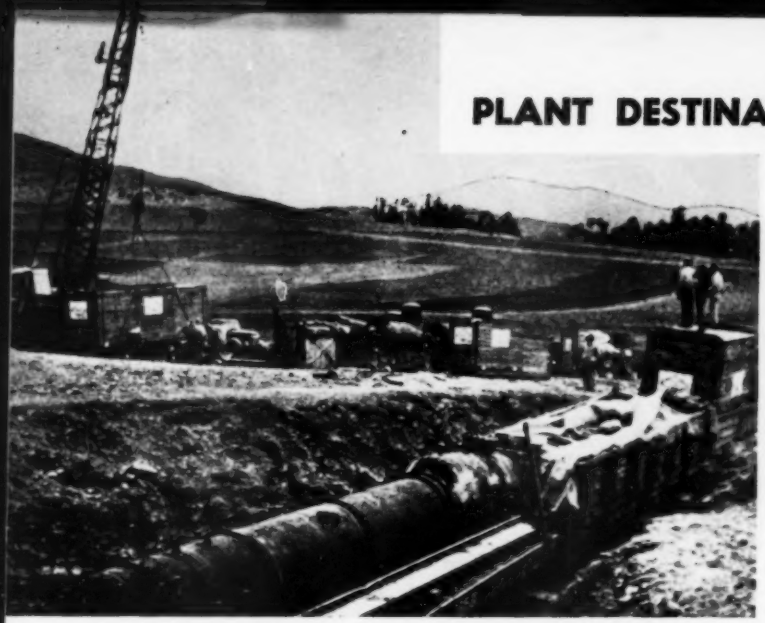
In the system using x-rays for the blending of tel. and gasoline, any inaccuracies in the flow ratio system due to errors in flow measurement are corrected by the x-ray analyzer and recorder. Since unleaded base stock flows through one cell of the instrument, and the base stock with tel. added flows through the other, the variations in base stock composition are automatically compensated for, so that the x-ray analyzer measurement is only of tel.

The x-ray instrument is present at a predetermined ratio of tel. fluid to gasoline for a particular blending run. While it is expected that the proper ratio will be held by the flow controller, if the x-ray controller sees a deviation from the present blend, its output loading pressure changes and repositions the tel. flow valve for the duration of the deviation.

Automatic control systems utilizing measurements of chemical properties might be discussed here. The reader will want to be cognizant of their existence and the expected development because the instrument user today is doing his utmost along these lines.

* * *

PLANT DESTINATION, BOLIVIA



Boxes of equipment, packed in Houston, arrive on plain near Sucre, Bolivia, at 9400-foot elevation where an oil refinery is being built by Foster Wheeler Corporation. Wood from the crates is the principal supply of lumber for construction work.

"Packaged" equipment required for handling on narrow-gauge road; actual construction of refineries are making good progress

A MAJOR industrial expansion program is now underway in Bolivia. The general program includes highway construction, irrigation projects, expansion of the present petroleum production facilities, construction of additional petroleum refining plants and construction of a crude oil pipe line from producing fields to refineries.

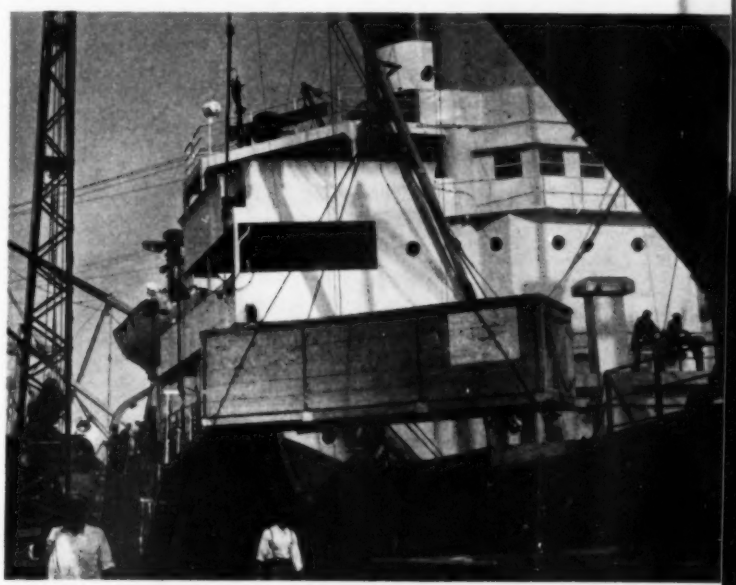
Foster Wheeler Corporation was retained to make a complete study of the petroleum refining expansion program with respect to the possible location of refineries and products to be obtained from the crude being produced. The program was suspended during the war, but resumed in 1947. Contracts were let in 1948.

The refining program consists of the construction of complete refineries at Sucre and Cochabamba. Bolivia straddles the Andes with most of its population on the central plateau of Alto Plano. La Paz, the largest city, is the highest city in the world with an elevation above sea level of 13,000 feet. The elevation of Sucre is 9400 feet and Cochobamba 8600 feet. Sucre is the capitol of Bolivia. Cochabamba, somewhat larger than Sucre, is the center of an industrial area.

Yacimientos Petroliferos Fiscales Bolivianos wanted a "temporary" 1000-barrel crude distillation unit erected at Sucre as soon as possible. Utilities for this plant consist of "oil-field" type boilers, prefabricated buildings, portable type electric power generators, etc. To follow the construction of this unit, the second Sucre project is to be a 3000-barrel crude distillation unit, complete permanent steam and electric power generation plant, with all other necessary utilities. Tankage, charge and product transfer piping and pumping capacity is sized for the ultimate plant capacity.

The Cochabamba refinery will be a 5000-barrel crude distillation unit with a light-ends unit for the production of aviation gasoline. This refinery will be complete with all necessary utilities. Construction will be started after the Sucre refinery is completed.

Water for the Sucre refinery is piped from a reservoir which supplies the city. There is sufficient difference in head to provide gravity flow to the refinery. Water treatment consists of a Zeolite unit only, which is to be utilized after erection of the complete refinery. Cooling water for the process is circulated through an induced draft cooling tower. The basin of the tower provides capacity for the fire control system, pumps for which are located at the basin. Water for the Cochabamba refinery is to be taken from an irrigation canal which passes through the refinery property. The water has a high turbidity even after its retention in a reservoir. The native clays are difficult to remove by simple sedimentation and a "sludge blanket" type precipitator will be used before the effluent is put through sand filters and a Zeolite treating system. Other water utilities similar to those for Sucre will be provided. In each refinery



Machinery crated by Lee Expert Export Crating Service is swung aboard a freighter bound for Antofagasta, Chile, and then on a narrow-gauge railroad over the Andes to Sucre, Bolivia, where a refinery is being built.

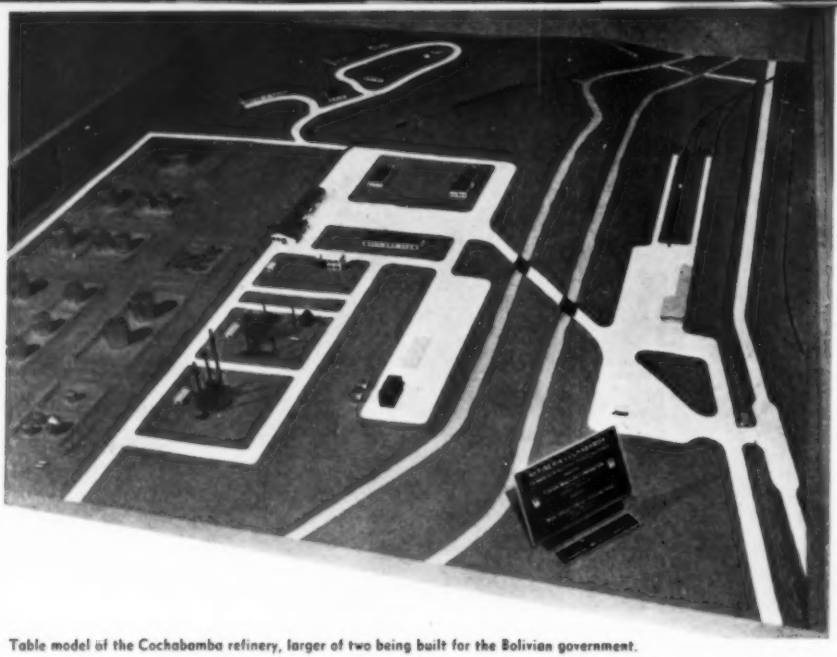


Table model of the Cochabamba refinery, larger of two being built for the Bolivian government.

there will be outdoor type steam generators.

A large portion of Bolivia's petroleum products is handled in steel barrels, largely due to lack of transportation facilities. With the construction of major links in her highway system, Bolivia will no doubt make greater use of tank trucks. Railroad spurs are being brought into each refinery from nearby railroads and each refinery is to have a barrel filling plant, railroad tank car loading rack and a truck loading dock.

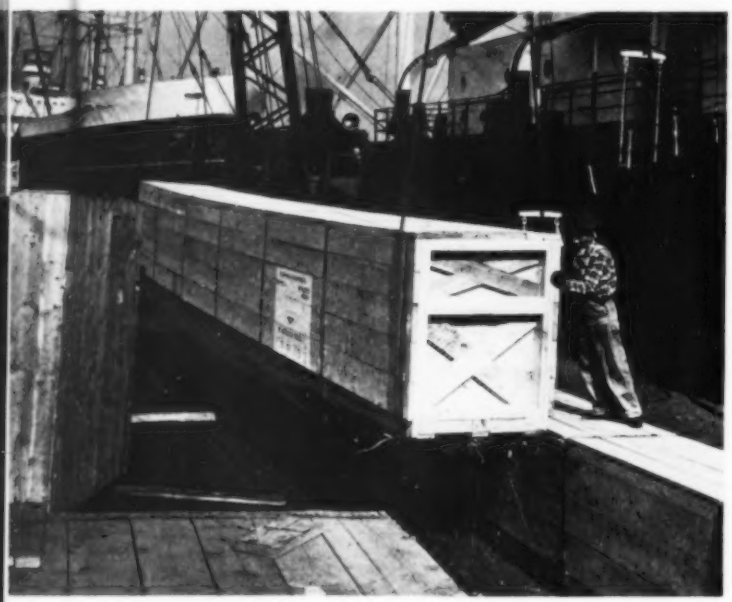
The machine shops in both refineries have been designed to handle all possible maintenance repairs. Each refinery will also have an administration building, laboratory, change house, clock and guard house and warehouse. Medical facilities have been provided for the Cochabamba refinery and even major operations can be made in emergencies. Cochabamba also has a cafeteria, recreation center and dormitories.

Bolivia has no seaport. The Chilean ports, Arica and Antofagasta are used for export and import traffic by Bolivia. All materials for the two refineries are handled through Antofagasta. A narrow gauge railroad from the port connects with a north-south line which branches off to Sucre and to Cochabamba. At points along the line the railroad climbs up to 17,000 feet. The distance to Sucre is 670 miles and to Cochabamba is 700 miles.

The maintenance problems of the railroad are terrific. This particular area of the Andes consists of unstable sedimentary formations which, during the rainy season continually fail, with disastrous effect on railroad traffic. Among the first items to be shipped to Bolivia were additional spare parts for the locomotives. The movement of many thousands of tons of heavy equipment strains the facilities of Antofagasta and the railroad rolling stock. The capacity of the trains is limited by the excessive grades and the movement of traffic is very slow due to the switchbacks in the long climb.

Lee Expert Export Crating Service is packaging the equipment for export from Houston. In order to reduce the number of actual "packages" shipped and to provide longer lengths of lumber for use in construction, as form lumber, at the beginning of the operation, ten tons was not considered too heavy. As the movement of materials proceeded, the weights have been reduced until the final limitation has been set at 2½ tons.

All required materials must be shipped from the United States excepting only cement. Since spare parts for the maintenance of construction tools are unavailable, all parts of equipment subject to possible failure must be provided, to avoid the necessity of shipment by air freight. The time required for equipment travel varies between two and three months.



Another big "package" of refinery equipment being loaded at Houston and consigned to Bolivian refinery site.

Applications of Thermodynamics To Hydrocarbon Processing

PART XX—Vapor-Liquid Equilibrium in Non-Ideal Systems

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THE vapor-liquid equilibrium ratio was defined in the previous installment as: $K = y/x$, where y and x are mol fractions of any component in the vapor and liquid, respectively. Also fugacity relationships were developed for estimating the equilibrium ratio. In addition to general fugacity relationships, the "ideal mixture" special case equations embodying the Lewis and Randall fugacity rule, were derived.

Pure component fugacities and activity coefficients, developed from perfect gas law deviations were presented in the previous installment and the method of applying these in the estimation of ideal mixture equilibrium ratios was illustrated. Also the various methods of plotting fugacities and K values were discussed and illustrated. With this background, the more complex problem of "non-ideal" K values can be discussed.

Literally, the term "non-ideal" applies to Cases II, IV and V, of the five cases listed in Part XIX (PETROLEUM REFINER, May, 1949) but Case II (i.e., where the vapor is a perfect gas as well as an ideal mixture) may be eliminated from consideration at this time because it is a special case of Case IV and because the vapor phase is seldom a perfect gas in hydrocarbon processing. It is frequently difficult to distinguish between Cases IV and V, the difference being ideal vapor mixtures in Case IV and non-ideal vapor mixtures in Case V. Generally speaking, neither phase is an ideal mixture in systems encountered in hydrocarbon operations. One reason for this is the high pressures normally employed in these processes. Accordingly, the best general approach to the problem is to consider Case V (i.e., vapor as a non-ideal mixture of real gases and liquid as a non-ideal solution) as the basis for all equations and development procedures.

Analytical and experimental methods may be used to determine the non-ideal equilibrium constants. From PVT data for mixtures, the fugacities of the different components in the mixture may be computed by the application of the proper thermodynamic equations. Different procedures may be employed in making these calculations. A noteworthy contribution along these lines is the development and application of an empirical equation of state by Benedict et al.[2]

The experimental method is to determine the compositions of equilibrium vapor and liquid for a mixture. From these compositions, values of y/x can be readily computed for each component in the mixture, thus avoiding fugacities. Although the experimental method gives the desired answers directly, there is no way of telling how much of the deviation from ideality is in the vapor phase and how much is in the liquid phase.

***VAPOR-LIQUID** equilibrium ratios for non-ideal mixtures may be obtained by thermodynamic calculations from PVT data for the system in question, by experimental measurements or by combination of these procedures. Resulting equilibrium ratios are usually correlated and applied by means of correction factors that take into account the system composition, temperature and pressure. The separate correlation of vapor and liquid fugacities is suggested in this installment and one method of accomplishing this is outlined.*

Experimentally determined K values of hydrocarbons are frequently correlated by constructing charts of average or smoothed data and supplementing these plots with correction factors that adjust the main chart readings for the character of the system, i.e., the other hydrocarbons present. In this way the deviations from ideal solutions are included in the two parts of the correlation; namely: the main chart and the correction factors. Where this correlation method fits experimental results, it is satisfactory for design purposes. An objection to this correlation method is that the designer has no way of telling the magnitude of the deviations from ideality.

Regardless of the method used to determine equilibrium ratios, or the method used to correlate these data, the values of K for all components become unity at the critical temperature and pressure of the mixture because at this point no component separation by phases is possible. Along with this condition there is a correlary requirement and that is the convergence of the K values to unity at temperatures below the mixture critical temperature. The pressure at which this convergence takes place is called the convergence pressure.

The estimation and application of the convergence pressure concept will be discussed in a later installment.

A clear understanding of terms is important in a study of phase equilibrium. This is particularly true of the words "ideal" and "non-ideal," which are applied here to the additivity and non-additivity, respectively, of the volumes of components of a mixture. The word "ideal" is not applied to the perfect gas law behavior of a vapor.

Hadden[20] calls his smoothed and correlated experimental K values "ideal Ks" to distinguish them from values that have been corrected for the character of the heavy component and the approach to the critical pressure. It seems more logical to use the term "ideal fugacity" to define K values derived from PVT data and the Lewis and Randall fugacity rule.

Non-Ideal Relationships

Expressions for non-ideal vapor-liquid equilibria may be derived from the fundamental thermodynamic functions with the proper definitions of reference states and then evaluating the activity coefficients from experimental data. There have been many such derivations, using different standard states and frequently being limited to particular systems and/or conditions. It is of interest to discuss some of these in this installment. Specific reference will be made to the work of Carlson and Colburn,[4] Gamson and Watson,[6] and Wohl.[13] No attempt will be made to cover all the literature on this subject.

Starting with the fugacity condition for equilibrium

$$\bar{f}^{V} = \bar{f}^{L} \qquad (336)$$

an expression for the equilibrium vaporization ratio, $K = y/x$, in terms of activity coefficients, can be derived by mathematical manipulations. In this derivation the subscript "O" will be used to designate the standard state, the superscripts "V" and "L" to designate vapor and liquid phases and the bar above the "f" symbol to designate the value of the fugacity in a mixture.

Dividing the left side of equation 336 by f_o^V and multiplying by its equivalent while making a similar manipulation to the right side gives

$$\left(\frac{\bar{f}^{V}}{f_o^{V}}\right) f_o^{V} y\, \gamma_o^{V} = \left(\frac{\bar{f}^{L}}{f_o^{L}}\right) f_o^{L} x\, \gamma_o^{L} \qquad (352)$$

where: γ_o^V and γ_o^L are defined by

$$\bar{f}_o^{V} = f_o^{V}\, y\, \gamma_o^{V} \qquad (352A)$$

$$\bar{f}_o^{L} = f_o^{L}\, x\, \gamma_o^{L} \qquad (352B)$$

Introducing f^V/f^V into the left side and f^L/f^L into the right side of equation 352 and rearranging gives

$$K_{non\text{-}ideal} = \frac{y}{x} = \left(\frac{f^{L}}{f^{V}}\right) \frac{\left(\dfrac{\bar{f}^{L}}{f^{L}} \Big/ \dfrac{f^{L}}{f_o^{L}}\right)}{\left(\dfrac{\bar{f}^{V}}{f^{V}} \Big/ \dfrac{f^{V}}{f_o^{V}}\right)} \frac{\gamma_o^{L}}{\gamma_o^{V}} \qquad (353)$$

If the reference state for the vapor is at zero pressure, γ_o^V will be unity. This is frequently, but not always, the case.

In equation 353 there are five fugacity ratios. The first one (f^L/f^V) is the ratio of the pure component liquid and vapor fugacities at the system temperature and pressure. This ratio may be found by equation 351 (Part XIX). In each of the other four fagacity ratios, the numerators and denominators apply to the same phase, as indicated, there being a ratio for the component pure and in mixture for both phases, liquid in numerator and vapor in denominator.

The γ_o^L and γ_o^V terms are the activity coefficients in the liquid and vapor reference states, as defined by equations 352A and 352B. The reference states may be chosen in such a manner as to make these two reference state activity coefficients unity. This is most likely for the vapor phase, however.

The selection of reference states is important in evaluating these fugacity ratios. Different reference states may be used for the liquid and vapor, but the two vapor fugacity reference states, (i.e., $\bar{f}_o^V$ and f_o^V) must be consistent and so must the two liquid reference states (i.e., $\bar{f}_o^L$ and f_o^L). With $\gamma_o^V = 1.0$, as may be the case in equation 353, the vapor reference state should be zero pressure. Equation 242 may be used to evaluate the vapor fugacity ratio. The liquid fugacity ratio may be evaluated by a similar equation, with the proper selection of the reference state.

If the reference states for the liquid and vapor fugacity ratios in equation 343 are chosen at conditions where Amagots' law of additive volumes and also the Lewis and Randall fugacity rule, as expressed by equations 345 and 346, apply, we may write:

$$\left(\frac{\bar{f}^{L}}{\bar{f}_o^{V}} \Big/ \frac{f^{L}}{f_o^{L}}\right) = \left(\frac{\bar{f}^{L}}{xf^{L}}\right) \qquad (354)$$

$$\left(\frac{\bar{f}^{V}}{\bar{f}_o^{V}} \Big/ \frac{f^{V}}{f_o^{V}}\right) = \left(\frac{\bar{f}^{V}}{yf^{V}}\right) \qquad (355)$$

Combining equations 353, 354 and 355 and noting that $\gamma_o^L = 1.0$ and $\gamma_o^V = 1.0$ for the conditions under which equations 354 and 355 apply, we obtain

$$K_{non\text{-}ideal} = y/x = \left(\frac{f^{L}}{f^{V}}\right) \frac{\left(\dfrac{\bar{f}^{L}}{xf^{L}}\right)}{\left(\dfrac{\bar{f}^{V}}{yf^{V}}\right)} \qquad (356)$$

Rearranging gives

$$K_{non\text{-}ideal} = y/x = \frac{(\bar{f}^{L}/x)}{(f^{V}/yP)P} \qquad (357)$$

where:

P = system pressure

$\bar{f}^L/x$ = activity coefficient of the component in the liquid phase

$\bar{f}^V/yP$ = activity coefficient of the component in the vapor phase

Equation 357 is an interesting and useful equation as will be demonstrated later. Equations 353 and 357 were developed to illustrate the importance and the effect of the reference state. Wohl[12] developed an equation similar to equation 353, selecting the reference state so $\gamma_o^V = 1.0$, and showing how to evaluate the fugacity ratios.

Benedict et al.[2] developed an eight constant empirical equation of state and derived constants for pure hydrocarbons and mixtures thereof, and in this way were able to evaluate the activity coefficients in equation 357 from PVT data.

A similar relationship to equation 353 was developed by Gamson and Watson,[6] who developed an expression for the high pressure equilibrium vaporization ratio using as the standard reference states the pure component as a liquid (or a vapor) at the temperature and pressure of the system. The resulting expression for K is the product of the "ideal" K value and a function of the activity coefficients for the vapor and liquid phases, this function being a correction to the ideal K values, which is an advantage. A disadvantage of this method (and also equation 353) is that it is necessary to extrapolate the pure component f/P plots at lower than unity reduced temperatures. This is not a serious objection, however, as it has already been done in developing the ideal K value correlations (see Part XIX).

Expressed mathematically and making slight changes in symbols to be consistent with the nomenclature used here, Gamson and Watson's relationships for the non-ideal equilibrium vaporization ratio is

$$K_{non\text{-}ideal} = y/x = \left(\frac{f^{L}}{f^{V}}\right) \left(\frac{\phi^{L}}{\phi^{V}}\right) \gamma \qquad (358)$$

where: (f^L/f^V) = the ratio of pure component liquid and vapor fugacities at the system temperature and pressure (see equations 351 and 353).

$\phi^L = \dfrac{\bar{f}^{L}}{\gamma x f^{L}}$ = activity coefficient of component in liquid phase, ϕ^L taking into account deviations from ideal solutions due to differences in molecular size or volatility.

γ = liquid phase activity coefficient which takes into account deviations from ideal solutions due to differences in molecular type.

$\phi^V = \dfrac{\bar{f}^{V}}{yf^{V}}$ = activity coefficient of a component in the vapor phase with the fugacity of the pure component at system conditions as the standard state.

The activity coefficient γ in equation 358 is not the same as γ_o^L in equation 353, as can be seen by comparison of equations 353 and 358, which are very similar.

Equation 351 (Part XIX) is a special case of equation 358 (and also equation 356) when the activity coefficients in the latter are unity. The ϕ^V and ϕ^L activity coefficients may become unity and the γ activity coefficient be other than unity, however.

In addition to the above equation, Gamson and Watson present a method of evaluating the ϕ^V and ϕ^L activity coefficients. This method employs the pseudo-critical concept and generalized correlations. The γ activity coefficient must be evaluated from experimental data.

The procedure given by equations 353, 356 and 358 is of interest because it permits using existing ideal fugacity K values to find the K values for non-ideal systems by multiplying by the indicated activity coefficients. It

is believed that this advantage is more than offset by the additional complexities involved in evaluating the required activity coefficients. Later a different, but similar, method, based on the use of equation 357, will be suggested for hydrocarbon systems.

TABLE 54
Comparison of f/P values from Lewis and Kay (Figure 62) and Kirkbride[10] Correlations

	$T_r = 0.80$		$T_r = 1.0$		$T_r = 1.2$		$T_r = 1.5$	
P_r	Fig. 62	Ref. 10	Fig. 62	Ref. 10	Fig. 62	Ref. 10	Fig. 62	Ref. 10
0.5	0.655	0.82	0.82	0.92	0.91	0.97	0.96	1.0
1.0	0.425	0.67	0.65	0.87	0.82	0.94	0.92	1.0
1.5	0.263	0.53	0.495	0.81	0.74	0.91	0.885	1.0
2.0	0.156	0.42	0.39	0.77	0.66	0.88	0.85	1.0
2.5	0.090	0.34	0.33	0.72	0.60	0.86	0.82	1.0
3.0	0.070	0.26	0.29	0.68	0.545	0.84	0.80	1.0

Suggested Procedure

For many years process engineers have known that corrections for deviations from ideal solutions were required for both the vapor and liquid activity coefficients of hydrocarbon mixtures. Had all the deviations from ideal mixtures been in the liquid phase it would be a simple matter to obtain correction factors from experimental vapor-liquid equilibrium data and ideal fugacities and to correlate the correction factor as functions of the liquid phase composition for future use in estimating K values for design work. Unfortunately, this is not the case and there is no shortcut way of telling how to prorate the corrections to vapor and liquid activity coefficients.

Most correction factors proposed for K values are identified with a given system and frequently defined for specific temperatures and pressures. These correction factors are thus limited in application so that considerably more experimental data are required to cover a given system and range of conditions than would be necessary with a more general correlation. Such a correlation might be developed if experimental K data could be taken apart to give the liquid and vapor activity coefficients.

In 1945, Kirkbride[10] proposed an empirical fugacity correlation, developed from experimental K values, as a method of calculating non-ideal fugacity coefficients for both vapor and liquid phases. This empirical correlation was a plot of fugacity/pressure ratio vs. reduced pressure for lines of constant reduced temperature, resembling Figure 62 (Part XIX), but not agreeing with it, as indicated by the comparison given in Table 54.

The values of f/P from the empirical correlation of Kirkbride are appreciably higher than the values of f/P from Figure 62.

Figure 62 is an ideal fugacity/pressure correlation, while Kirkbride's is for non-ideal systems. For this reason the two correlations would not be expected to agree. However, the differences are so great as to make one wonder when to use one chart and when to use the other. It would appear that there are intermediate systems where neither could be used.

Kirkbride's empirical f/P correlation was developed from experimental data by using K values for several pressures at one temperature for a given system. From the lowest pressure (about one atmosphere) K value, the fugacity of the liquid at its vapor pressure was obtained by assuming that the vapor fugacity was equal to the system pressure thus getting the liquid fugacity at the system pressure by $f_P^L = (K_{obs})\ (f_P^V)$ and then using a method similar to equation 350 and Figure 66 (Part XIX) for computing $f\pi^L$ from f_P^L. This value of $f\pi^L$ was then used in analyzing higher pressure experimental K data at the same temperature. In these higher pressure computations the liquid fugacities were computed by starting with the value of $f\pi^L$ found in the first low pressure computation and making the effect of pressure calculation, as mentioned above. From the value of f_P^L thus found, the value of f_P^V is found by the relation $f_P^V = f_P^L/K_{obs}$. Values of f_P^V/P (more conveniently called f/P) were then computed. As calculations proceeded, the f/P chart was constructed as values from this diagram were required in making further calculations. In this pyramid fashion Kirkbride calculated f/P values and constructed plots and cross plots of f/P for hydrocarbons.

A generalized and smoothed correlation of these f/P ratios was then prepared from the results of analyzing data on several systems. The resulting f/P chart can only be used for estimating vapor-liquid equilibrium ratios where ratios of fugacities rather than actual values are used. This chart could not be used for homogeneous equilibria calculations.

Although this method was shown to agree with observed K values better than previous fugacity/Pressure correlations it appears that an even better generalized method can be developed by estimating the vapor phase fugacity first and then finding the liquid fugacity from the experimental K and the vapor fugacity instead of the reverse, as Kirkbride did it. This seems indicated because the vapor phase more closely approaches ideal mixtures than the liquid phase under the same conditions.

It appears that the best procedure would be to determine values of (f^V/yP) and (f^L/x) by the combination of a generalized solution for the vapor plus experimental K values and then to correlate the activity coefficients with reduced properties of the respective vapor and liquid phases rather than to attempt the development of one universal activity coefficient plot for both vapor and liquid.

With separate activity coefficient correlations, additional correlation factors, such as those given by Hadden[7] may not be necessary, at least they would be simpler.

Gamson and Watson[6] and Joffe[8] have proposed generalized methods using the pseudo-critical concept for evaluation of the activity coefficient for a component in a vapor mixture. Benedict[1] also developed such a method several years ago but selected the equation of state method instead for use in computing values of (f^L/x) and (f^V/yP) for equation 357.

The application of the Benedict et al. equation of state method to the computation of activity coefficients from PVT is laborious, requiring skillfully performed machine calculations. There is no question about the precision of the results, if properly done, however. A calculation program on the thermodynamic properties of hydrocarbon mixtures would logically include activity coefficients. Such a job is too big for any one company to undertake. Most process design engineers are satisfied with the use of generalized thermodynamic properties, using the pseudo-critical concept for mixtures.

Consistent with this generalized approach would be the computation of vapor phase activity coefficients by generalized methods and the evaluation of liquid phase activity coefficients by a combination of experimental data and the values of the vapor phase activity coefficient thus computed. This is the method suggested here as an alternate to the equation of state method.

In this manner experimental K values for non-ideal systems could be taken apart to give the numerical values of (f^L/x) and (f^V/yP). Any

inaccuracies in the experimental data or the values of $(\bar{f}^v/yP)$ found by the pseudo-critical generalized method would be reflected in the values of $(\bar{f}^L/x)$, thus obtained. This is an objection to the suggested method, but not a serious problem. Such a procedure should make the correlation of experimental K values much easier and more logical than direct correlation of K values.

Theoretically this pseudo-critical generalized method might be applied to both vapor and liquid phase, as suggested by Gamson and Watson,[6] if liquid mixture densities could be accurately represented by a generalized correlation using the pseudo-critical. This extreme is not recommended.

Vapor Activity Coefficients

An equation will now be derived for computing the activity coefficient of a component in a vapor mixture. This mixture will be based on the use of the pseudo-critical concept proposed by Kay.[9] The initial steps of a similar development of Joffe[7] will be employed and the final equation will be similar to that derived by Benedict[1] and disclosed to the writer.

The equations to be derived are valid only when the compressibility and the isothermal effect of pressure on enthalpy of a gas mixture can be represented as a generalized function of the reduced temperature and pressure. The reliability of these correlations have been demonstrated in previous installments.

The effect of composition on the fugacity of a component in the mixture is related to the fugacity of the entire mixture by an equation derived by partial differentiation with respect to the composition variables. In terms of the mol fraction, the fugacity of the "i^{th}" component in the vapor phase as a function of fugacity of the entire mixture was developed by Joffe.[7] Using a "y" symbol for the mol fraction in the vapor phase instead of the "x" symbol used by Joffe and dividing each fugacity term by pressure to give an activity coefficient, results in the following:

$$\ln\left(\frac{\bar{f}_i^v}{Py_i}\right) = \ln\left(\frac{f_m^v}{P}\right) + \frac{\partial \ln \frac{f_m^v}{P}}{\partial y_i} \qquad (359)$$

where: $\frac{\bar{f}_i^v}{Py_i}$ = activity coefficient of the i^{th} component in the vapor phase.

$\frac{f_m^v}{P}$ = activity of the entire mixture.

Equation 359 is a shorthand writing of the complete equation and is adequate for these purposes.

The dependence of f_m^v/P on composition may be expressed as follows:

$$\frac{\partial \ln \frac{f_m^v}{P}}{\partial y_i} = \left(\frac{\partial \ln \frac{f_m^v}{P}}{\partial T_r}\right)\left(\frac{\partial T_r}{\partial y_i}\right) + \left(\frac{\partial \ln \frac{f_m^v}{P}}{\partial P_r}\right)\left(\frac{\partial P_r}{\partial y_i}\right) \qquad (360)$$

where: $T_r = \frac{T}{T_{pc}}$ = the reduced temperature of the mixture based on its pseudo-critical temperature.

$P_r = \frac{P}{P_{pc}}$ = the reduced pressure of the mixture based on its pseudo-critical pressure.

Using Kay's[9] definition of the pseudo-critical, as given in equations 193 and 194 (Part X), the reduced temperature and pressure relationships are:

$$T_r = \frac{T}{\Sigma y T_c} \qquad (361)$$

$$P_r = \frac{P}{\Sigma y P_c} \qquad (362)$$

Differentiating equations 361 and 362 with respect to y_i, recognizing the fact that there are only n—1 independent composition variables, gives:

$$\frac{\partial T_r}{\partial y_i} = -\frac{T}{[\Sigma y T_c]^2}(T_{c_i} - T_{c_n}) \qquad (363)$$

$$\frac{\partial P_r}{\partial y_i} = -\frac{P}{[\Sigma y P_c]^2}(P_{c_i} - P_{c_n}) \qquad (364)$$

Equations identical to equations 363 and 364, but with slightly different symbols, were derived by Joffe.[7]

In applying these equations, it is necessary to define the n^{th} component, which may be any component in the system. Accordingly, we may select the most convenient component, which will be the one having a critical point equal to the pseudo-critical of the mixture. If there is not an actual component fulfilling this requirement, the n^{th} component will be a hypothetical component. In either case, we may write:

$$T_{c_n} = \Sigma y T_c \text{ and } P_{c_n} = \Sigma y T_c$$

Combining these relations for the n^{th} component's critical values with equations 363 and 364 gives

$$\frac{\partial T_r}{\partial y_i} = T_r\left(1 - \frac{T_{c_i}}{\Sigma y T_c}\right) \qquad (365)$$

$$\frac{\partial P_r}{\partial y_i} = P_r\left(1 - \frac{P_{c_i}}{\Sigma y P_c}\right) \qquad (366)$$

where: T_r and P_r = the reduced conditions of the entire gas mixture.

T_{c_i} and P_{c_i} = the critical conditions of the "i^{th}" component.

y_i = mol fraction of the i^{th} component in the gas mixture.

$\Sigma y T_c$ and $\Sigma y P_c$ = the pseudo-critical conditions for the entire gas mixture.

Other equations required in this development are the effects of temperature and pressure on the activity coefficient. These may be derived from quations given by Dodge[5] on pages 240 and 242 of this thermodynamics text. These equations are:

$$\left(\frac{\partial \ln \gamma}{\partial P}\right)_T = \left(\frac{Z-1}{P}\right)$$

$$\left(\frac{\partial \ln \gamma}{\partial T}\right)_P = \frac{H^\circ - H}{RT^2}$$

Rewriting these equations in terms of the appropriate units gives:

$$\left(\frac{\partial \ln \frac{f_m^v}{P}}{\partial P_r}\right)_{T_r} = \left(\frac{Z-1}{P_r}\right) \qquad (367)$$

$$\left(\frac{\partial \ln \frac{f_m^v}{P}}{\partial T_r}\right)_{P_r} = \left(\frac{-\Delta H}{T_c}\right)\left(\frac{1}{RT_r^2}\right) \qquad (368)$$

Combining equations 360, 365, 366, 367 and 368, gives the following equation for the effect of composition on the activity coefficient of the mixture:

$$\frac{\partial \ln \frac{f_m^v}{P}}{\partial y_i} = \left(\frac{-\Delta H}{T_c}\right)\frac{1}{RT_r}\left(1 - \frac{T_{c_i}}{\Sigma y T_c}\right) + (Z-1)\left(1 - \frac{P_{c_i}}{\Sigma y P_c}\right) \qquad (369)$$

Combining equations 359 and 369, gives the following equation for the activity coefficient of the i^{th} component in a vapor phase mixture:

$$\ln\left(\frac{\bar{f}_i^v}{Py_i}\right) = \ln\frac{f_m^v}{P} + (Z-1)\left(1 - \frac{P_{c_i}}{\Sigma y P_c}\right) + \left(\frac{-\Delta H}{T_c}\right)\frac{1}{RT_r}\left(1 - \frac{T_{c_i}}{\Sigma y T_c}\right) \qquad (370)$$

where: $\frac{f_m^v}{P}$ = a generalized function of T_r and P_r for the mixture and may be found from Figure 62 (Part XIX) or from Table 20 (Part XII).

$\frac{-\Delta H}{T_c}$ = a generalized function of T_r and P_r for the mixture and may be found from Figure 48 (Part XVI).

Equation 370 is similar to the equation developed by Benedict[1] and analogous to the equations developed by Joffe[8] and by Gamson and Watson.[6] It is somewhat simpler than the analogous equations of Joffe[7] and of Gamson and Watson.[6] It can be seen by inspection that the activity coefficient of a component having critical constants equal to the pseudo-critical constants of the mixture will be equal to the activity coefficient of the entire mixture.

The accuracy of equation 370 de-

pends upon how well the pseudo-critical generalized correlations of Z, f/P and $(-\Delta H/T_c)$ apply to hydrocarbon mixtures. It has been shown that the generalized correlations for compressibilities and the effect of pressure on the enthalpy may be applied to mixtures with sufficient accuracy for the usual vapor density and enthalpy balance calculations. It does not follow from this, however, that these correlations are good enough for phase equilibria computations. This must be determined by a careful analysis of data.

As an example in the application of equation 370, the vapor phase activity coefficients will be computed for the components of the binary: 80 wt. percent methane and 20 wt. percent ethane at 70° F. and 2000 psia., and the results compared with the experimental values of Sage and Lacy,[11] and the values obtained from ideal fugacities, as developed in Part XIX and presented in Figure 62.

The pseudo-critical conditions are:

	COMPOSITION		CRITICAL TEMP.		CRITICAL PRESSURE	
	Wt., %	Mol. %	T_c °R	$y\,T_c$	P psia.	$y\,P_c$
Methane	80.0	88.23	344	303	673	594
Ethane	20.0	11.77	550	65	709	83
	100.0	100.00		368		677

The pseudo-critical constants for the mixture are 368° R. and 677 psia. With these the reduced conditions for the system are:

$$T_r = \frac{460 + 70}{368} = 1.44$$

$$P_r = \frac{2000}{677} = 2.96$$

From Figure 19 (Part IX), the value of the compressibility factor for the mixture is found to be: $Z = 0.775$. Figure 19 is not to a large enough scale for the precision required in these calculations. From Figure 48 (Part XVI), the value of the isothermal effect of pressure on the enthalpy is found to be:

$$\frac{-\Delta H}{T_c} = 3.3$$

From Figure 62 (Part XIX), the value of the mixture's activity coefficient is found to be:

$$\frac{f_m^v}{P} = 0.76$$

This value of f_m/P was found to be too high, as determined by the results obtained by substituting in equation 370. From Table 20 (Part XII), the value of f_m^v/P was found, as follows:

At $T_r = 1.44$ and $P_r = 2.96$, by interpolation, $k_1 \ln f/P = 0.410$

For $k_1 = -1.38$, the average value indicated previously,

$$\ln \frac{f_m^v}{P} = -0.297$$

and

$$\frac{f_m^v}{P} = 0.745$$ as compared to 0.76 found from Figure 62.

The value of f_m/P found from Table 20 will be used because these values were obtained by the same work done in developing Figure 48, giving $(-\Delta H/T_c)$ values for use in applying equation 370.

Substituting in equation 370 for each component separately:

Methane

$$\ln \frac{\bar{f}^v}{Py} = -0.297 + (0.775 - 1.0)\left(1 - \frac{673}{677}\right) + \left(\frac{3.3}{1.987 \times 1.44}\right)\left(1 - \frac{344}{368}\right) = -0.22455$$

$$\left(\frac{\bar{f}^v}{Py}\right)_{CH_4} = 0.799$$

Ethane

$$\ln \frac{\bar{f}^v}{Py} = -0.297 + (0.775 - 1.0)\left(1 - \frac{709}{677}\right) + \left(\frac{3.3}{1.987 \times 1.44}\right)\left(1 - \frac{550}{368}\right) = -0.855$$

$$\left(\frac{\bar{f}^v}{Py}\right)_{C_2H_6} = 0.426$$

The values of the activity coefficients will be compared with the values obtained by assuming ideal solutions, i.e., the Lewis and Randall fugacity rule. Figure 62 will be used for both components because Table 20 cannot be applied to ethane at its reduced conditions.

Methane

$$T_r = \frac{530}{344} = 1.54$$

$$P_r = \frac{2000}{673} = 2.97$$

From Figure 62

$\frac{f}{P} = 0.82$ for pure methane at 70° F. and 2000 psia.

Ethane

$$T_r = \frac{520}{550} = 0.964$$

$$P_r = \frac{2000}{709} = 2.82$$

From Figure 62

$\frac{f}{P} = 0.24$ for pure ethane at 70° F. and 2000 psia.

The results from the above calculations are compared below with the observed data of Sage and Lacey in the following tabulation.

Activity Coefficient of Components in 80 wt. percent Methane 20 wt. percent Ethane Binary at 70° F. and 2000 psia.

	Observed Sage and Lacey[11]	Ideal System Figure 62	Non-Ideal System Equation 370
Methane	0.791	0.82	0.799
Ethane	0.372	0.240	0.426

While the values of these activity coefficients obtained by equation 370 are closer to the observed values than are the values from Figure 62, this one point comparison is not sufficient to indicate the accuracy of the method.

It is evident that careful calculations with consistent and accurate values of f/P, Z and $(-\Delta H/T_c)$ are necessary for the proper application of equation 370. If equation 370 is applied in the manner visualized, i.e., computing the vapor activity coefficients for equation 357 and then finding the liquid activity coefficients from experimental data via the application of equation 357, any inaccuracies in the results from equation 370 will be compensated for in the resulting liquid activity coefficients.

Liquid Activity Coefficient

Theoretically, an equation similar to equation 370 could be applied to the liquid phase with generalized correlations of the activity coefficient of the entire mixture, the compressibility factor and the isothermal effect of pressure on the enthalpy for the liquid phase, if these properties are unique functions of the pseudo-critical reduced conditions.

For this case the equation similar to equation 370 for the liquid would be as shown in Equation 371, top of next page.

The differences between equations 370 and 371 are in the activity coefficient of component "i" and the mixture and in the Z term. Note that the vapor equation 370 has a P in the

$$\ln\left(\frac{\bar{f}_i^L}{x_i}\right) = \ln f_m^L + Z\left(1 - \frac{P_{ci}}{\Sigma x P_c}\right) + \left(\frac{-\Delta H}{T_c}\right)\frac{1}{RT_r}\left(1 - \frac{T_{ci}}{\Sigma x T_c}\right) \quad (371)$$

denominator of the activity coefficient whereas the liquid phase equation does not. Accordingly, the (Z—1) term of equation 370 becomes Z in equation 371.

All the terms in equation 371 apply to the liquid phase. The correlations given in this series for Z and $(-\Delta H/T_c)$ are not applicable to liquid mixtures. Such correlations might be developed but this author does not recommend computing liquid phase fugacities by generalized methods until there are better basic correlations for the liquid phase.

Gamson and Watson[6] derived a generalized equation for the liquid fugacity and also developed the required correlations for applying the equation.

Values of (f/x) for the components of the liquid phase may be obtained by starting with pure component fugacities and correcting for the effects of pressure and composition by the application of an equation of state. Because of limited space this method will not be discussed. The reader is referred to an article by Benedict et al[2] on this subject.

Much of the "non-ideal" system vapor-liquid equilibrium work that has been published has been for systems that were non-ideal in the liquid phase and ideal, or close thereto, in the vapor phase. In many cases the vapor phase is even a perfect gas. For these cases, the vapor phase fugacities are easily obtained, leaving the liquid phase as the one requiring derived fugacities.

For this situation it is convenient to write equation 356 in the following form by making $(f^V/yf^V) = 1$.

$$K = y/x = \left(\frac{f^L}{f^V}\right)\gamma^L \quad (372)$$

where:

f^L/f^V = the ideal fugacity K value from equation 351

γ^L = the activity coefficient of the liquid phase.

If the vapor phase obeys the perfect gas law as well as being an ideal mixture, equation 372 becomes:

$$K = y/x = \frac{\pi}{p}\gamma^L \quad (373)$$

The value of γ^L for equations 372 and 373 are usually obtained by experimental vapor-liquid equilibrium measurements and then correlated by empirical methods. These correlation methods are based on an important thermodynamic relation known as the Gibbs-Duhem equation. Some of the equations derived therefrom are known by the following names of their authors: Van Laar, Margules and Scatchard.

These equations have been applied to experimental data and constants determined by Berg and McKinnis,[3] by Carlson and Colburn,[4] by White,[12] by Wohl,[13] and by many others. Equations of this type have found their widest application in correlating data on binary systems forming constant boiling mixtures. For most hydrocarbon work these equations are not very useful because: (a) multi-component systems, rather than binary systems, are usually encountered and (b) hydrocarbon systems have ideal solution deviations in both phases rather than concentrated in the liquid phase.

In the next installment, experimental methods of obtaining vapor-liquid equilibrium data and empirical methods of correlating these data will be discussed.

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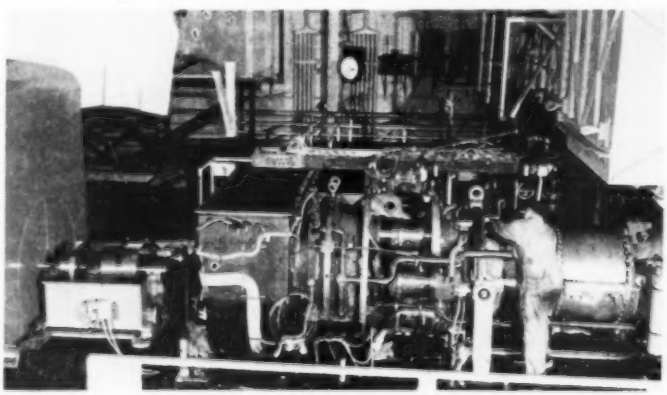
(End of Part XX. Part XXI will appear in an early issue.)

* * *

First Combustion Gas Turbine Power Plant in U. S.



The first combustion gas turbine power plant to be built and sold in this country for central station use is shown as it was on test at the General Electric Company plant in Schenectady, N. Y. The unit, rated 3500 kw, was being built for use by Oklahoma Gas and Electric Company.

The unit, shown here without the exhaust duct connected, was the first combustion gas turbine power plant in a public utility in this country for generation of electricity.

General View of Standard Oil Company of California's New Packaging and Grease Plant at Richmond.

"Push-Button" Factory for Oil Products

STANDARD Oil Company of California's new package and grease plant, now in operation at the Richmond refinery is virtually a push-button factory for the manufacture of more than 250 miscellaneous petroleum products. The 7½-acre unit also furnishes storage and shipment space for nearly every product the company puts in packages.

The basement floor resembles a miniature railroad switchyard, with one mile of roller conveyors, along which the heavy drums are "switched" at a rate of one every three seconds, by electronic controls to railroad spur tracks, to truck loading docks and to storage. Many of the plant's unique features were designed to the specifications of Standard's engineers.

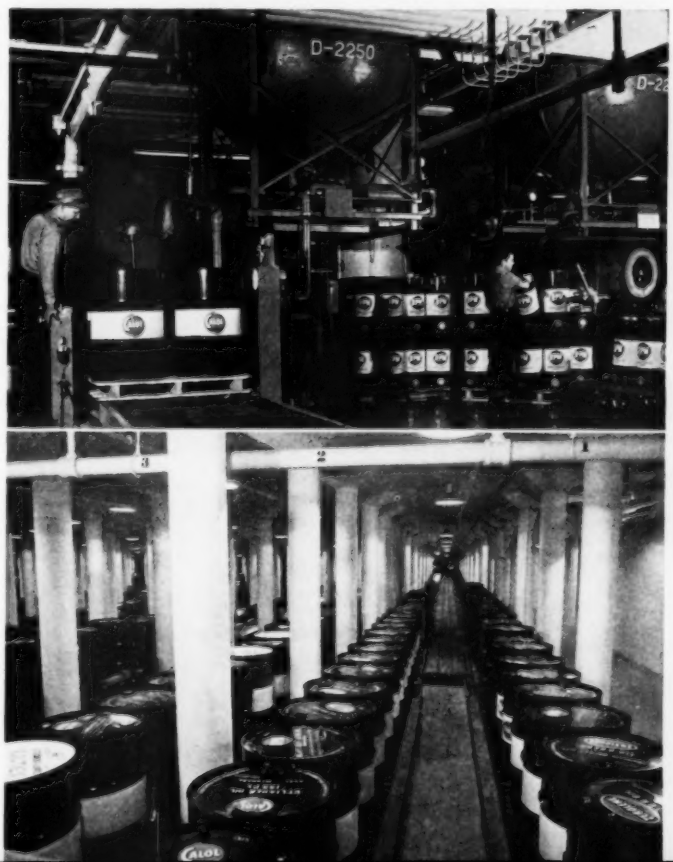
Stocks are moved through 20 miles of pipe lines which lace the building. Greases, lubricants and specialties, production of which is at the rate of 38 million pounds a year, are mixed in 29 automatic mixers, with capacities of from ten to 75 barrels per batch.

On eight spur railroad tracks running under its roof the plant can accomodate up to 32 box cars at a time.

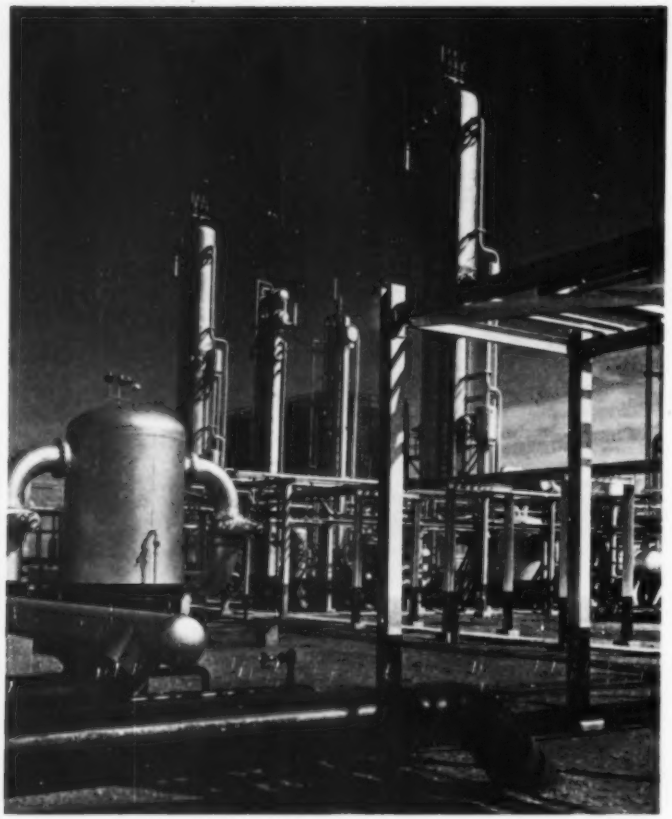
Nine can-filling units make up the lubricating oil packaging section. One of the units can fill and cap 48,000 quart cans of oil in a working day, moving at a rate of two cans per second. Another, filling 2½-gallon tins, handles 6000 of these larger containers in an eight-hour period.

The warehousing section of the plant stocks approximately 1000 items, which are handled by 10 fork trucks, 11 trans stackers, two tractors, and 42 trailers. Of this range of products, 43 percent are represented in average daily shipments, two-thirds of which are sent by rail, and one-third by truck.

The greasemakers, on the average, have worked for the oil company for 27 years, and have spent an average of 19 years in the manufacturing department. The service records of the packaging and shipping workmen in this plant are equally impressive.



Top photo (at right)—Filling Barrels in Grease Section of California Standard's Richmond plant. Bottom photo: Automtic conveyors segregate carloads of products in basement section to await shipment.



The photograph above shows the south inlet gas scrubber, fuel gas treating area, and absorbers of the TXL gasoline plant built in a joint Shell-Texaco venture near Odessa, in West Texas. This plant has been in operation now for several months.

TXL Gasoline Plant

Exceeds Original Design Capacity

Shell Oil Company-Texas Company joint project near Odessa, Texas, started only last year but is already expanding

FOR the purpose of processing gas from wells in the surrounding TXL and Wheeler fields, Shell Oil Company in a joint venture with The Texas Company has constructed the TXL plant, a compression-absorption type natural gasoline plant, near Odessa, in West Texas. The plant started operation in 1948 and already has exceeded its original design capacity of 30 million cubic feet per day.

The plant is presently recovering the condensable components from 50 million cubic feet per day of raw gas, with additional capacity to be added later. Design of the plant permits production of a 26-pound vapor pressure natural gasoline and 90-pound vapor pressure liquefied petroleum gas and excess propane. The stripped residue gas is then returned to the leases for repressuring and other purposes. The plant is a direct major contribution to the vast conservation program in which the state and the oil and gas companies are allied.

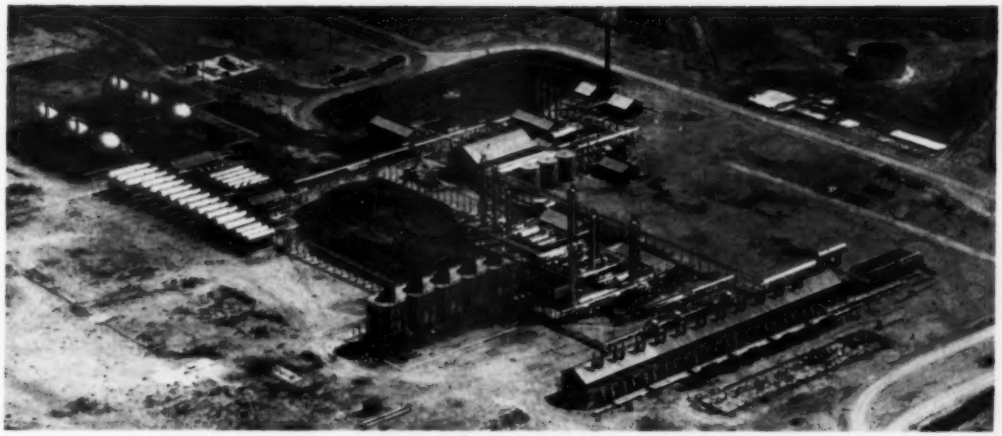
Production from the TXL and Wheeler fields is from the Devonian and Ellenburger zones at depths of approximately 8000 and 10,000 feet, respectively. Current oil production averages about 25,000 barrels per day from 105 wells in the TXL field and 23 wells in the Wheeler field. The extensive field gathering system is composed of parallel intake and residue lines extending to all leases supplying gas.

Shell's gas-gasoline department supervised the building of the plant and maintains the operating staff; whereas construction was by Brown & Root, Inc. of Houston. Main vessels in the plant, which operates at an absorption pressure of about 200 psig., are an absorber, high-pressure still, low-pressure still, deethanizer, depropanizer, and debutanizer. Four 150-horsepower boilers each deliver about 20,000 pounds per hour of steam at 250 psig. pressure. Casinghead gas processed in the plant is compressed in two stages, one dicharging at 40 psig. and the second at 200 psig. in 11 angle-type, 8-cylinder gas driven compressors.

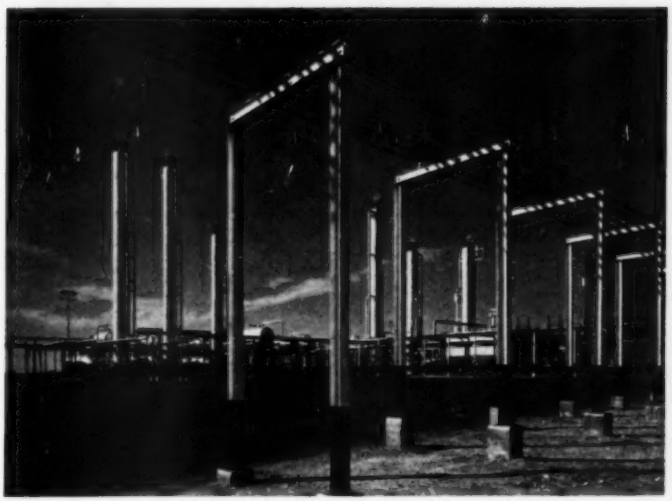
The plant contains its own electrical power generating station, which consists of four alternating current generators each producing 665 kva. The generators are driven by 8-cylinder gas engines, each delivering 760 horsepower.

Since the plant location is in a semi-arid section, water cooling is supplemented by large air-cooling units, which are used for the compressor engine jacket water and the overhead products streams on the high-pressure still and low-pressure still.

Construction of a new compressor building is presently underway to house eight new compressors, part of an expansion program.

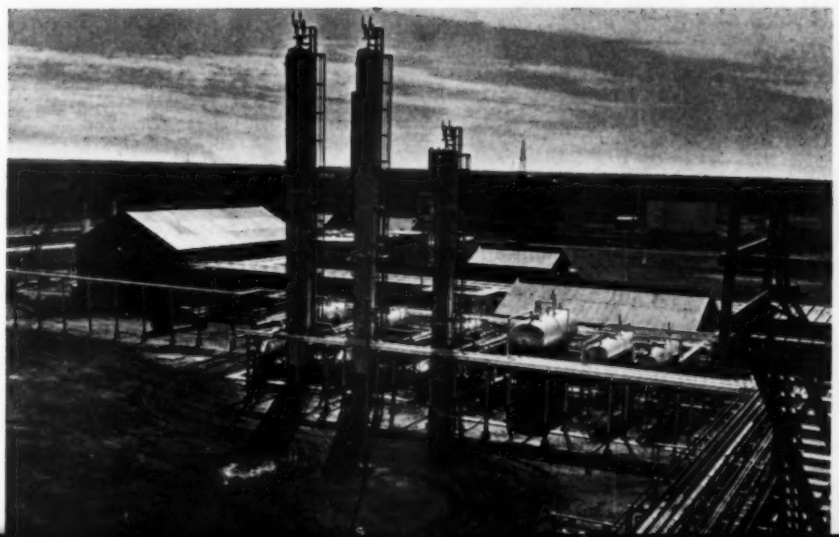


Photo, above, showing layout of the Shell-Texaco TXL plant near Odessa, Texas, was taken from the northwest. Two large air coolers are used to supplement the conventional type cooling tower due to the scarcity of water in that semi-arid section.



Right—Process area of the TXL gasoline plant, which is designed to permit production of 26-pound vapor pressure natural gasoline and 90-pound vapor pressure liquefied petroleum gas and excess propane.

Below—Generator building and fractionation area of the TXL gasoline plant. Designed for 30,000,000 cubic feet daily of gas from the TXL and Wheeler fields, the plant is presently processing 50 million cubic feet daily.



Central Shop Will House All Mechanical Crafts

Modern sound-proof, air-conditioned building is part of Humble's program of expansion at Baytown refinery

HUMBLE Oil & Refining Company is building a central shop in its Baytown refinery, which eventually will house all mechanical crafts—pipefitters, machinists, welders, insulators, carpenters, instrument men, electricians, bricklayers, painters, blacksmiths, tinners, and other skilled personnel of the plant. The building shown under construction in the accompanying pictures, covers more than 98,000 square feet, approximately two and one-quarter acres.

The new modern, air-conditioned, sound-proofed building is in keeping with Humble's program of expansion and improvement throughout the refinery. Present shops can no longer serve the refinery requirements as efficiently as formerly, due to the greatly increased size of the plant and resulting complex operation. Some of the refinery shops already have moved into the new quarters.

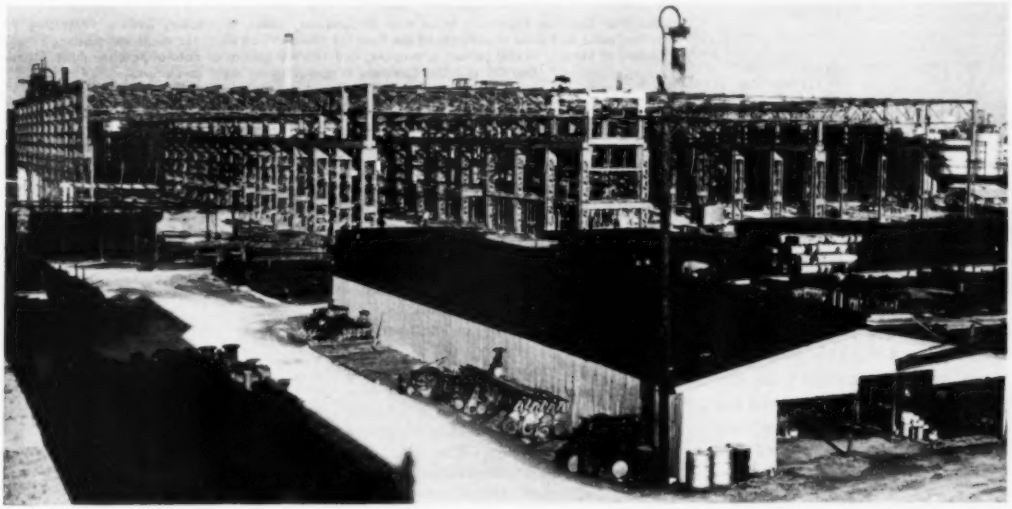
Additional working space will be provided for the crafts in the new building. New tools and equipment will be installed in the building, which will be arranged to insure each craft the best possible working conditions. It is expected that there will be a minimum of delay on that repair work which must pass through several different shops. This will result in increased efficiency and better service.

Air-conditioning equipment, utilities lines, offices for individual crafts, and some locker and storage space will be contained in the center section, which runs the length of the building. The main locker and washroom will be located centrally.

Arrangements in the building provide two long sections of working space, on each side of the shop offices which will be separated by walls and partitions into individual shops. Each working section will be equipped with overhead cranes traversing the full length of the section. Fixed cranes will handle local lifting and moving jobs. Mercury vapor and incandescent lamps will be used for lighting, and each shop will be made as soundproof as possible.

The walls of the building will be built of corrugated asbestos siding on a 7-foot brick base. Both walls and roof will be insulated with glass wool, the roof consisting of galvanized metal lath, glass wool blankets, 4-inch light rock slabs, and a layer of asphalt felt.

Above—Humble Oil & Refining Company's new central shop building, to house eventually all the plant's mechanical crafts, containing floor space of over 98,000 square feet under construction in the Baytown refinery. Workmen are laying the roof consisting of metal lath, glass wool blankets, light rock slabs, and asphalt-felt. Sides of the building will be corrugated asbestos siding on a seven-foot brick base.

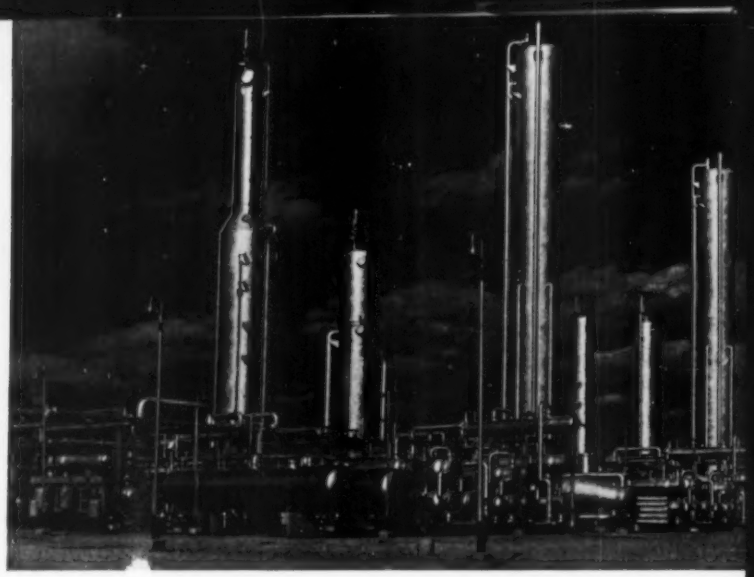


Center Picture—The air-conditioning equipment, utilities lines, offices for individual crafts, and some locker and storage space will be contained in the middle section which runs the entire length of the building. Sections on either side of the center will be divided into working space for individual shops by walls and partitions.

At Right — Workmen laying glass wool blanket over metal lath on the roof of Humble's central shop building. The glass wool is followed by a layer of light weight rock slabs and then asphalt-felt.

Split-Flow Gas Sweetening Unit Features Slaughter Plant

J. S. BELLAH, R. V. MERTZ, J. W. KILMER
Stanolind Oil & Gas Company, Tulsa



Slaughter Gasoline Plant 4½ miles west of Sundown, Texas, in Hockley County. Processing 90 million cubic feet daily of casinghead gas from the Slaughter oil field, the plant will produce 92,000 gallons of butane, 50,000 gallons of propane, and 100,000 gallons of natural gasoline daily. Stanolind Oil and Gas Company is operating for eight co-owners.

THE SLAUGHTER gasoline plant supplies further evidence of the combined efforts of the oil companies to effect economic utilization of natural gas that was being wasted. This new plant will process 90 million cubic feet daily of gas that formerly was burned in flares, because there was no use for it in West Texas.

Dedication ceremonies of the plant were held May 14. More than 1500 guests, including employes and executives of oil companies operating in the Slaughter field, state officials, and civic leaders of the area, attended the ceremonies and the barbecue at the plant site.

Among the engineering design features of the plant is a split-flow gas-sweetening unit, a fractionating reabsorber to deethanize the rich oil, and an indirect heating system supplying 90 percent of the process heating load.

ONE of the world's largest high-pressure casinghead gasoline plants recently went into operation in the Slaughter field of West Texas. This plant, located 12 miles southwest of Levelland, is an outstanding example of cooperation by a group of companies seeking the economical and maximum utilization of natural resources.

The eight companies which are joint owners are Stanolind Oil and Gas Company, The Texas Company, Honolulu Oil Corporation, Magnolia Petroleum Company, The Devonian Company, The Atlantic Refining Company, Saltmount Oil Company and Mid-Continent Petroleum Corporation. Stanolind, the largest owner, and the operator, has a participation of only a little more than 25 per cent.

The Slaughter field, in Cochran, Hockley and Terry counties, was discovered in 1936 and is the third largest oil field, in acreage, in the United States. As presently developed it contains some 75,000 acres.

More than 97 per cent of the 2000 oil producing wells in the field are connected to the gasoline plant gathering system. Plant equipment is installed initially to process 90 million standard cubic feet daily with an increased capacity up to 120 million cubic feet possible by the addition of a relatively small amount of equipment.

Design recovery of liquid products, when processing 90 Mmcf. of gas having the composition shown below, is approximately 50,000 gallons per day of propane, 92,000 gallons per day of butanes and 100,000 gallons per day of debutanized gasoline. All residue gas except that used for plant and lease fuel is being sold to El Paso Natural Gas Company.

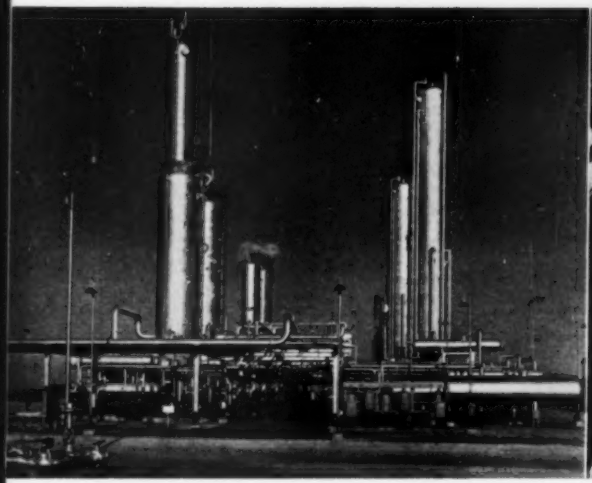
Design Gas Composition

COMPONENT	Mol Percent
Hydrogen Sulfide	1.0[a]
Carbon Dioxide	5.9[b]
Nitrogen	10.4
Methane	59.3
Ethane	10.5
Propane	6.4
Butanes	3.7
Pentanes	1.7
Hexanes and Heavier	1.1
	100.0

[a] Hydrogen Sulfide may range up to 1.5%.
[b] Carbon Dioxide may range up to 7.5%.

The plant incorporates a number of interesting process and mechanical features, including 1) a "split-flow" Girbotol unit to sweeten the field gas; 2) a fractionating reabsorber designed to deethanize the rich oil, making it practical to operate with only one stripping still and eliminating the necessity for a separate deethanizer; and 3) an indirect heating system, employing oil as a heat medium, which supplies about 90 percent of the process heating load, thus reducing the size of the steam plant.

The plant is designed to recover 32 percent of the propane, 85 percent of the butanes and 99 percent of the pentanes and heavier content of the wet



Process area of Slaughter gasoline plant. Plant capacity is 90 million cubic feet daily; however, the field gathering system is designed for 120 million cubic feet daily, so that plant capacity can readily be increased to the gather system capacity by installation of additional processing equipment.

North Compressor House. Plant has 16 1600-horsepower compressors, 10 in the north building. Total compressor horsepower is 25,600—a little more than the power of four modern diesel freight locomotives. Compressor installation is world's largest devoted to casinghead gas processing.

field gas. Design recovery was set at the maximum possible consistent with heating value specifications of the residue gas.

Designed and constructed by C F Braun & Co in cooperation with

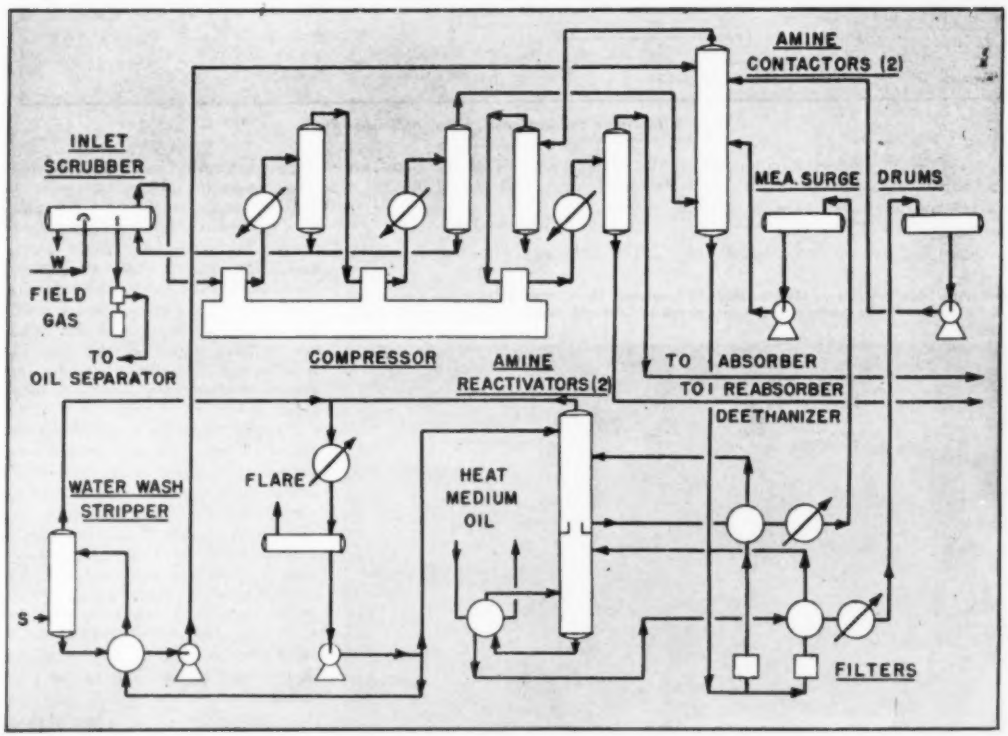


Figure 1. Compression and H_2S Removal, Slaughter Gasoline Plant.

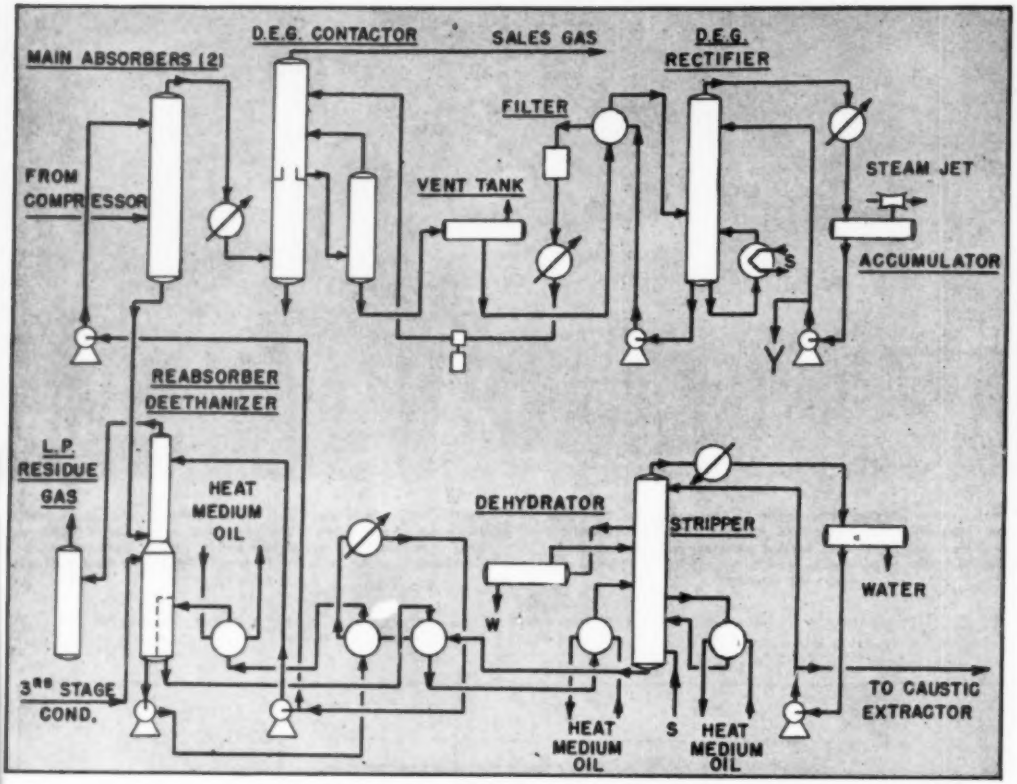
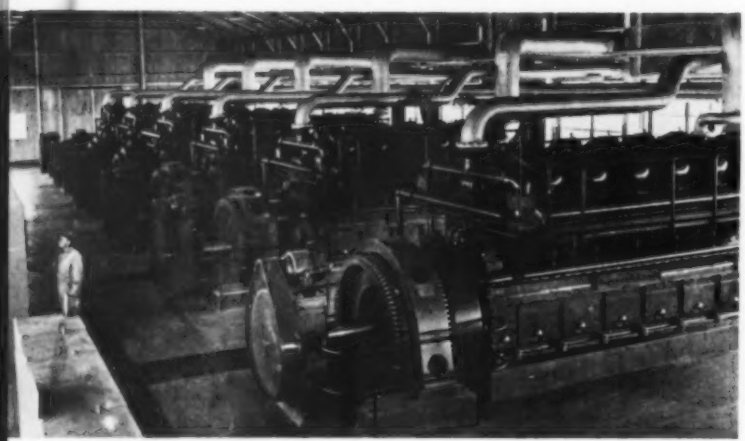


Figure 2. Absorption and Distillation, Slaughter Gasoline Plant.

a committee of engineers representing the various plant owners, the plant started operation February 15, 1949, a month ahead of schedule.

Simplified process flow diagrams of the various sections of the plant are shown in Figures 1, 2 and 3.

Generator house contains six 800-kw., 2300-volt generators. Electrical power produced is equivalent to that needed by the combined populations of nearby Levelland, Sundown, and Brownfield, Texas.



Field System

The field gas gathering system is designed to collect gas from field separators operating at approximately 10 psig., delivering it to the gasoline plant at a pressure slightly above atmospheric. The entire gathering system is designed to operate above atmospheric pressure in order to eliminate the possibility of air infiltration which would be undesirable because of the hydrogen sulfide content of the gas. The field system includes a residue gas system to return dry sweet gas to all leases.

The plant field gas compressors consist of sixteen 1600-hp. (sea level rating) 2-cycle, right angle, gas engine driven units designed to compress approximately 90 Mmcf. daily from 13.2 psia. to 713 psia. Each machine is equipped with three stages of compression designed with sufficient flexibility to compress 10 percent additional gas by an increase in suction pressure to 18.2 psia. These compressors are derated to approximately 1500 bhp. each at the 3000 feet altitude of the plant location.

Field gas enters the plant through a 12-foot x 40-foot horizontal scrubber designed to remove entrained crude

oil, scale and other foreign material. Gas from this scrubber flows to the compressor first stage suction header at essentially atmospheric pressure, and is compressed through two stages to approximately 180 psig. The second stage discharge gas is cooled, passed through a separator and flows to the hydrogen sulfide removal system where H_2S and CO_2 are removed by contacting with a water solution of monoethanolamine. Sweet gas from the amine contactors passes through residue scrubbers, enters the third stage of compression at approximately 165 psig., and is compressed to 700 psig., the operating pressure of the main absorber.

Future addition of four 1600-hp. compressors will increase the plant capacity to 120 Mmcf. daily.

H_2S Removal System

A flow diagram of the H_2S removal system is indicated in Figure 1. Because of the relatively high content of acid gas (H_2S and CO_2) a "split-flow" Girbotol amine system was installed. This system, by utilizing partly stripped monoethanolamine for removal of a large proportion of the acid gas, effects economy in utilities consumption over the conventional amine system.

Sour field gas from the second stage of compression after cooling, is divided and processed in two independent parallel amine systems, each designed to sweeten a maximum of 60 Mmcf. daily. Each of the 28-tray contactors is 9 feet x 65 feet and normally operates at 175 psig. Gas leaving the contactors is essentially free of CO_2 and is negative to the lead acetate test for H_2S. When processing 90 Mmcf. daily of sour field gas, the total circulation of 30 percent monoethanolamine for both amine systems is some 1100 gpm.

In this "split-flow" process, a portion of the total rich amine stream is completely stripped and returned to the top of the contactor. The other portion, only partly stripped, is returned to the contactor on either the sixteenth or twelfth tray from the bottom. The rich amine is split and introduced into the reactivator at two points. That portion flowing down the top half of the reactivator is only partly stripped, while the portion flowing down the bottom half is essentially completely stripped. Details of the cycle are shown in Figure 1.

In this process a major portion of the acid gas content of the field is removed by partly stripped amine solution, and further reduction to lead acetate quality is assured by final contacting with completely stripped solution. Elimination of the necessity of completely stripping the entire amine circulation results in substantial reducton of utilities consumption.

Each of the two reactivators is 8 foot 6 inches x 80 foot 10½ inches and is equipped with 33 bubble cap trays, the seventeenth tray from the bottom being a chimney tray.

Overhead vapor from the reactivator, consisting of acid gas and steam, passes though an overhead cooler which serves to condense the major portion of the steam. Part of this condensate is returned to the reactivator top tray as reflux, and the remaining portion is stripped of acid gas and pumped over wash trays in the tops of the contactors to minimize loss of

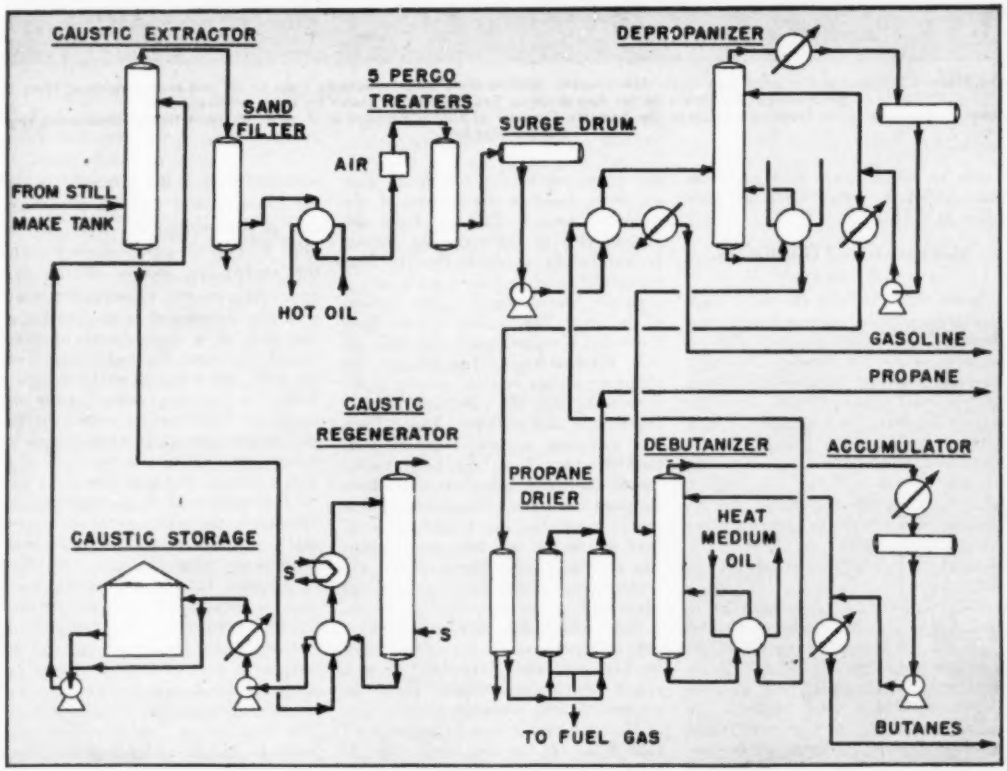
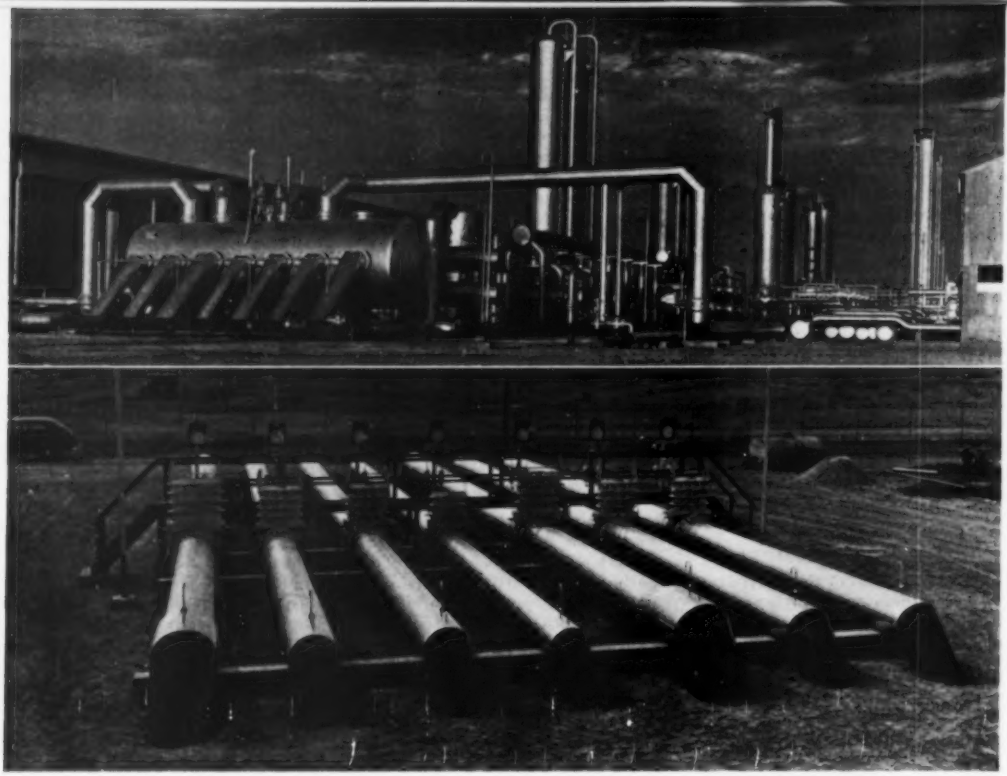


Figure 3. Product Treatment and Fractionation, Slaughter Gasoline Plant.



Top Photo—Compressor and absorber area of the new Slaughter gasoline plant. North compressor house at left and south compressor house at right. Vessels at the left are the two main absorbers. Gas scrubbers and coolers are in the left foreground.
Lower Photo—Meter Runs. Incoming casinghead gas from the Slaughter oil field is measured as it enters the plant through these seven large diameter pipe lines.

amine to residue gas. Acid gas from the reactivator reflux accumulator flows to a flare line.

Absorption and Distillation System

Sweet rich gas from the third stage discharge scrubber enters two 6 foot 6 inches x 46 foot 0 inches main absorbers, each containing 25 trays. Normal operating pressure is 693 psig. Design lean oil circulation over the main absorbers, for a 90 Mmcf. daily processing rate, is 585 gpm. The combined residue gas goes to a single diethylene glycol unit for dehydration. Rich oil from the bottom of the absorbers, along with condensate from the third stage scrubber, flows to the reabsorber deethanizer operated at 137 psig.

The reabsorber deethanizer is equipped with 45 bubble cap trays, 25 in the 10 foot 6 inches x 53 foot 0 inches stripping section and 20 in the 5 foot 0 inches x 32 foot 0 inches absorption section. Rich oil from the main absorber, together with third stage condensate, enters on the twenty-fifth tray. Part of the lighter absorbed hydrocarbons flash and rise through the tower while the remaining rich oil flows down to the bottom of the stripping section. Rich oil from the bottom tray of the stripping section is reboiled by pumping through heat exchangers and is flashed back into a separate compartment in the bottom of the tower. Deethanized rich oil flows from this compartment to the rich oil still. Flashed vapors rise through the stripping section counter-current to the descending rich oil, effectively removing ethane and methane. Vapor from the stripping section, together with flashed vapor from the feed, enters the 20-tray absorption section where propane and butane loss to the residue gas is controlled by introduction of lean oil to the top tray at a design rate of 155 gpm. Residue gas from the reabsorbers deethanizer is used as plant fuel.

Deethanized rich oil exchanges heat with stripped lean oil, is further heated by heat medium oil to 400° F. and enters the rich oil stripper (still) on the twelfth tray from the bottom.

The stripper, 9 foot 6 inches x 61 foot 6 inches, is equipped with 20 trays. The normal operating pressure is 67 psig. Partly stripped rich oil is withdrawn from the eleventh tray of the tower, passes through a reheater and is returned to the tenth tray at 485° F. This oil passes down through the stripping section of the still counter-current to stripping steam which is introduced to the bottom of the still at a design rate of 9000 pounds per hour. Flashed vapors from the feed, together with stripped vapors from the stripping section, enter the upper or fractionating section of the still where lean oil is washed back by reflux returned to the top tray at a design rate of 230 gpm. Since the rich oil feed to the still is substantially deethanized, the still overhead is normally completely condensed. The overhead make from the still, consisting of propane, butanes and natural gasoline, is pumped through the product treating system to the fractionators.

Hot lean oil from the bottom of the stripper is heat exchanged against the rich oil feed and against the reabsorber deethanizer reboiler stream. The lean oil is finally cooled with water to 85° F. and pumped back to the main absorber and reabsorber. Refer to Figure 2.

Residue Gas Dehydration

Cooling residue gas from the main absorbers is dried by contact with 97-98 weight percent diethylene glycol in a 6 foot 6 inches x 30 foot 1 inch 7-tray contactor. The bottom section of this contactor serves as a knock out drum. Normal operating pressure is 688 psig.

Diethylene glycol solution flows from a chimney tray in the contactor through a small level control drum to the DEG rectifier which is 2 foot 6 inches x 31 feet and contains 12 bubble cap trays.

In order to permit operation with maximum water dew point depression, provision is made for re-concentration of diluted DEG by vacuum distillation at 8-9 psia. By this method of operation, DEG concentrations of 97-98 weight percent may be attained without danger of decomposition.

Concentrated diethylene glycol from the bottom of the rectifier is cooled and returned to the top of the contactor. Design circulation rate when processing 90 Mmcf. daily is approximately 10 gpm.

A flow diagram of the residue gas dehydration unit is shown in Figure 2.

Liquid Product Treating

The high mercaptan sulfur content of the Slaughter field gas makes it impractical to treat the gasoline in a conventional stationary bed copper chloride treater without pre-treatment to reduce the mercaptan content. In the Slaughter plant, a regenerative caustic washing system serves this purpose. The raw gasoline stream from the still overhead accumulator is pumped through a 6 foot x 50 foot packed caustic contactor containing 30 feet of 1½-inch carbon Raschig rings. When operating at a processing rate of 90 Mmcf. daily the design solution circulation is 35 gpm. of 10 percent sodium hydroxide solution. This caustic circulation reduces the mercaptan sulfur content of the raw gasoline to a point where it is satisfactorily treated in fixed bed copper chloride treaters. Spent caustic from the bottom of the caustic contactor is regenerated by steam stripping in a 5 foot x 22 foot 6 inches tower equipped with eight bubble cap trays. The overhead from the caustic regenerator tower, consisting of steam and mercaptans, flows to a disposal stack.

Raw gasoline from the caustic contactor passes through sand filters for removal of caustic entrainment and into five fixed bed copper chloride contactors, each 72 inches x 12 feet, operating in parallel. This treatment converts the remaining mercaptan sulfur content of the raw gasoline to odorless and non-corrosive disulfides.

A solid desiccant dehydration unit is provided for propane drying.

Figure 3 includes a flow diagram of the product treating system.

Fractionation System

The treated product stream is heat exchanged with the debutanizer bottoms and pumped into the 36-tray 7 foot x 62 foot 6 inches depropanizer. Commercial propane is produced overhead from this column and flows to storage through a sand filter and solid desiccant dehydration unit. Design operating pressure of the depropanizer is 240 psig. The depropanizer bottom stream feeds the 40-tray 6 foot 6 inches x 68 foot 6 inches debutanizer which normally operates at 75 psig. A commercial butane product is produced overhead and flows through a product cooler to storage. Natural gasoline, which may range in vapor pressure from 12 to 26 pounds RVP, is produced as a kettle product. It exchanges heat with the depropanizer feed and flows through a cooler to storage.

Storage and Loading Facilities

Product storage has been installed for approximately five days' production when processing 90 Mmcf. daily. There are three 12 foot x 120 foot horizontal tanks for propane storage, five of the same dimensions for butane, two 7500-barrel spheroids for gasoline and two 10 foot x 70 foot gasoline rundown tanks.

Storage is also provided for 60,000 barrels of well water, 2000 barrels of lean oil, 1000 barrels of heat medium oil and 1000 barrels of boiler feed water. There is smaller capacity storage for caustic solution, amine, sulfuric acid and lube oil.

Truck and rail loading facilities are provided at the plant site.

Utilities

In order to hold the steam generation requirements to a minimum, essentially all of the process heating load is supplied by a hot oil heat medium system. Virgin gas oil is circulated through two direct fired heaters, rated at 60 million Btu per hour each, to the various process heat loads. Under design conditions, the heat medium oil leaves the direct fired heaters at 550° F. and returns at 360° F.

Process cooling water is circulated over a 20,000-gpm. induced draft cooling tower. Under design conditions cold water is pumped from the basin at 80° F. to shell and tube exchangers for process, interstage gas, jacket water and lube oil cooling. Water returns to the cooling tower at 120° F.

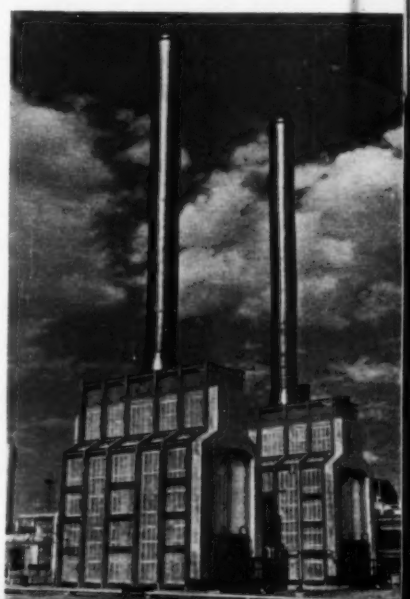
Raw water is supplied to the plant by four 500-gpm. wells located on the plant site.

Electric power is furnished by six 800-KW. 2300-volt 3-phase generators, each driven by a 1200-bhp. (nominal sea level rating) 4-cycle engine.

Steam is supplied at 300 psig. by two gas-fired water tube boilers, one of which is standby. Each boiler is rated at 30,000 pounds per hour. Normal steam demand for a 90 Mmcf. daily processing rate is about 22,400 pounds per hour. Most of this steam is used to drive the heat medium pump turbines which exhaust into a 125-psig. steam system. Steam from this system is used for process stripping, and in the DEG reboiler and regenerative caustic preheater. Several small turbines are driven by 300-psig. steam and exhaust at 10 psig. into the hot process boiler feed water treater.

The cold lime-soda process is used to treat cooling water make-up. Facilities are also provided for stabilization by addition of sulfuric acid and for chlorination of the cooling tower water to control algae and slime.

Waste disposal facilities include two 50 foot x 250 foot settling basins, a burning pit, an evaporation pit, a flare stack and an acid gas stack.



Heat Medium Furnaces. Most of the heat for processing is supplied by a heat medium, a special type of oil that is heated in these furnaces and then circulated about the plant. The oil leaves the furnaces at 550° F. and is returned at 360° F. About one million pounds of the special oil is circulated in the plant every hour.

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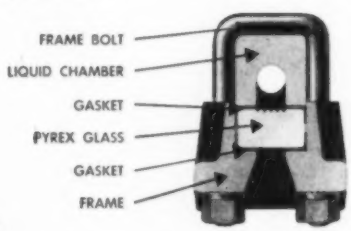

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REFINER AUTHORS and Other Personalities

Information, formal and otherwise, about the men who write for PETROLEUM REFINER as well as others prominent in the industry.

Stanolind Trio Describes Plant

THREE Stanolind Oil & Gas Company engineers collaborated to produce the article beginning on page 154 of this issue of PR, "Split-Flow Gas Sweetening Unit Features Slaughter Plant," which discusses the Slaughter oil field project and gasoline plant now on stream near Sundown, in West Texas.

J. S. Bellah was born in Birmingham, Ala., attended high school in Kentucky, college in Tennessee, was in Africa and Italy with the armed forces during the war, and now lives in Tulsa, where he is a mechanical engineering group leader with Stanolind.

While at the University of Tennessee, Bellah was a member of Tau Beta Pi and Phi Kappa Phi. He graduated as a chemical engineer in 1934. After graduation he did further work at the University for a year under a TVA scholarship.

He then joined Socony-Vacuum Oil Company in Kansas, as a refinery engineer, a position he held until 1941, when he became development project engineer for the Mathieson Alkali Works at Niagara Falls.

Bellah entered military service in 1942 as an Air Force technical ordnance officer. He served in Africa and Italy. After being discharged in 1945, he became a staff engineer in the Division of Industrial Cooperation of Massachusetts Institute of Technology.

In May, 1946, he joined Stanolind as a process engineer, and was project engineer on the Slaughter gasoline plant project. He and Mrs. Bellah have two daughters.

R. V. Mertz, who bears gracefully the nickname of "Tiny," joined Stanolind in 1946 as a chemical engineer in the newly organized manufacturing department. Prior to that time he was chief chemical engineer with Mid-Continent Engineering Company, Inc.

Tiny started to work after studying electrical engineering at Oklahoma A. & M. College. He joined Phillips Petroleum Company in 1930, was superintendent of operations in the Rice Plant at Borger for the manufacture of butadiene and aviation gasoline components, and supervised the initial operation of the country's only alkylation plant using aluminum chloride catalyst for production of diisopropyl. About this time he developed and patented a method for the prevention of corrosion in furfural systems used in butadiene purification.

But after eight years of work in the industry, Tiny went back to school and he took both a bachelor's and master's degree in chemical engineering. The master's degree he received under a fellowship granted by the American Gas Association for research.

Back into field work with Phillips, Tiny worked as an engineer in the West Texas district of the gasoline department. His experience with processing of sour gas came in quite handily in the Slaughter plant design for Stanolind, where he is a mechanical engineering group leader.

Tiny's hobbies are fishing and quail hunting, but at last reports Lady Luck had left him. The fish stopped taking any kind of bait, and the quail began to fly crooked.

James W. Kilmer is from the assembly-line-production town of Detroit. He is a graduate of Powell Military Academy, Powell, Indiana, (1930), and received his bachelor of science degree in 1934 from Rensselaer Polytechnical Institute, Troy, N. Y., in chemical engineering.

A few years later, when it was time to enter military service, he was chief engineer at Fostoria Pressed Steel Corporation at Fostoria, Ohio. Captain Kilmer five years and three months later, became plain Kilmer again and enrolled for graduate work in chemical engineering at Texas A. & M. College. In February, 1947, he went to work for Stanolind Oil & Gas Company.

GE Author Discusses Instrument Control

NELSON GILDERSLEEVE is author of "Analytical Instruments in Automatic Control Systems" which starts on page 133 of this issue. A 1940 graduate of Harvard University with a degree in engineering sciences, he is particularly concerned with the application of laboratory analysis instruments to automatic control system and has discussed this theme before the Pittsburgh analytical symposium, the Texas A. & M. short course for the process industries and sections of the Instrument Society of America.

Joining General Electric in 1940 Gildersleeve worked on the company's test program until 1943 when he entered the control engineering division. Soon he became a member of the special products division, working with specialized measuring equipment for process and quality control. Out of this work came application and market studies for instruments for chemical analysis.

Active in the Instrument Society of America, Gildersleeve was the first presi-

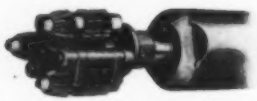
R. V. Mertz

J. S. Bellah

J. W. Kilmer

Nelson Gildersleeve

WITH THESE heads you win



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dent of the Eastern New York section and for two years was a member of the papers committee. At present he is a director of the national society as well as chairman of the sections and membership committee.

Ethyl Researchist Prepares Article

HAROLD J. GIBSON, who is coordinator of research on motor fuels and lubricants at the Ethyl Corporation Research Laboratories in Detroit, presented the subject, "Factors Affecting Octane Number Requirement" before the Society of Automotive Engineers annual meeting in January of this year. It is being used in this issue commencing on page 110.

Gibson has been associated with the Ethyl Laboratories since he received his degree from the University of Michigan in 1930. He also has a M.S. degree in engineering.

Before becoming research coordinator some five years ago, Gibson was a research engineer in the laboratories.

He is a member of SAE, Sigma Xi, Iota Alpha (honorary research fraternities), and represents Ethyl Corporation in the Motor Fuels Division of the Cooperative Fuel Research Committee of the Coordinating Research Council. He has been active in other CFR groups, also.

Houdry Foursome Are Collaborators

THE article beginning on page 117, "Various Refinery Applications of Houdriflow Catayltic Cracking" was prepared by four top-notch men of Houdry Process Corporation, Messrs. Peavy, Weinrich, Noll, and Hornaday.

It is a discusion about the new Houdry cat cracker and first presentation of the article was before the recent annual meeting of The Western Petroleum Refiners Association.

Dr. Claude C. Peavy, vice president in charge of sales and engineering of Houdry, has had many years experience in all phases of petroleum refining engineering, including catayltic cracking. He came to Houdry from the refinery engineering division, where he was chief process engineer, of Socony-Vacuum Oil Company. Before he became vice president, he was chief engineer for Houdry. Previous to the five years with Socony-Vacuum, Peavy had been an engineer for E. B. Badger and Sons Company and during these nine years he worked on the design of the first commercial Houdry fixed-bed units and also saw engineering service in foreign countries.

Harold J. Gibson

Whitney Weinrich, widely known for his prominence in affairs of the American Chemical Society as secretary of the division of industrial and engineering chemistry from 1939 to 1943, has the following to say about his hobby of farming: "My evenings and week ends are devoted to converting two acres of broom grass and other undesirable forms of plant life into a producing orchard and garden. My big trouble is to be able to recognize the correlation between the way plants grow in the row and the way 'the book says they do'. However, the acquisition of a graden tractor with an ever increasing number of gadgets mechanizes farming sufficiently to largely overcome a tendency to the armchair variety."

In addition to farming, some time still remains for Weinrich to devote to attending the Philadelphia Orchestra Concerts and the Robinhood Dell Concerts in the summer.

Weinrich joined Houdry as head of the pilot plant development in 1947. He was born in Honolulu, T. H., and received his formal education at the Massachusetts Institute of Technology, receiving his M. S. degree from MIT's school of chemical engineering practice.

The he went back to Hawaii but in 1933 he joined Gulf Oil Corporation's Philadelphia refinery as petroleum technologist. Later he was a Gulf Research Industrial Fellow at the Mellon Institute for specialized work but in 1935 he returned to Gulf's Pittsburgh laboratories. Weinrich headed the chemical engineering division of Gulf Research division, serving as staff assistant chemist for eight years.

During the war, Weinrich specialized in the toluene and aromatics progress handled by the refining division of PAW. After the war, Weinrich joined Phillips Petroleum Company as manager of the company's Bartlesville pilot plant section of the chemical engineering department. He left in 1946 to join the University of Pennsylvania's chemical engineering staff.

Currently, Weinrich is head of the chemical engineering section of the development division in Linwood.

Henry D. Noll, pipe smoker "extraordinaire," lists deep sea fishing as his chief sport and has a prize catch of a 300-pound tuna as just part of the supporting evidence. He also is modest about an excellent game of golf.

Noll, manager of the Houdry Engineering and Technical Service Division, came to Houdry after 19 years with Socony-Vacuum Oil Company, Inc. He attended the University of Colorado and

• CONTINUED ON PAGE 189

Claud C. Peavy

Whitney Weinrich

Henry D. Noll

George F. Hornaday

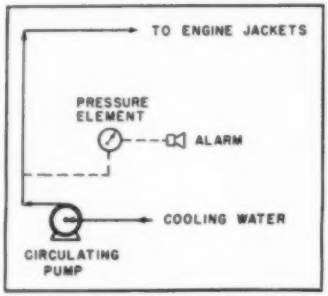
Maintenance and Operation—

HOW TO DO IT

HOW—
Alarm Signals Pump Shutdown

TO PREVENT compressor overheating, equipment damage, and possibly the shutdown of a process plant due to failure of the compressor jacket water circulation, an alarm system was installed in one cycling plant as shown in the accompanying sketch.

A pressure sensitive element located on the discharge line of the jacket water circulating pump actuates the alarm whenever pump pressure falls off through



pump motor failure or other causes. The alarm warns the operator that the flow of jacket cooling water to the compressors has stopped. The auxiliary or standby pump is then placed in operation.

Since this alarm ordinarily will anticipate the occurence of high engine temperatures, due to cooling water flow failure, it is effective in preventing those unexpected compressor engine stoppages, caused by the standard engine overheat cutout devices.

HOW TO—
Save Vented Lube Oil

THE superintendent of a cycling plant noticed that the accumulation of oil around the outlet of the vent line from the crankcase of the high-pressure compressors was making an untidy and hazardous area in the plant. Also, he found that the vapors contained a considerable quantity of entrained lube oil.

To clean up the vapors before venting them, a small scrubber with a mist extractor was set up as shown in the photograph. The mist extractor on the side of the scrubber has a return line to the scrubber base.

The scrubber solved the problem of keeping the area around the vent line outlet free of oil. In addition, when the oil that accumulated in the scrubber was checked, it was found to be uncontaminated and ready for returning to the crankcase of the engine. Installation of the scrubber has reduced the lube oil makeup requirements of the engines to a comparatively small volume.

HOW—
Alarm Prevents Sump Overflow

THE installation in the accompanying photograph is designed to pump waste oil-water and seepage water from the sump in a pump house having a floor several feet below the ground. The motor-driven pump is controlled by a float switch.

As an added precaution to prevent overflow of the sump, a high-level alarm float switch has been installed alongside the pump. If the switch or pump does not work and the level of the water and oil in the sump rises above the predetermined high level for operation of the pump, the high-level alarm switch lights a large red alarm light installed in the center of the pump room. The light is large enough to attract the attention of the operator from any point in the building. The alarm provides the operator with an opportunity to check operation of the pump and prevent overflow of the waste liquid over the floor of the pump room.

How can you judge a refinery's performance *before it's built?*

NO INDUSTRY depends to a greater degree on the efficiency of its physical plant than the petroleum processing industry.

Your best indication of the performance of your projected plant lies in the past record and experience of the organization which will design and build it.

McKee's long record of engineering successful processing facilities in all quarters of the globe is safe assurance of the reliable performance to be expected from McKee-engineered plants.

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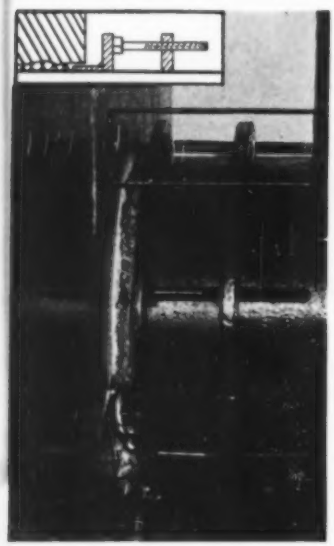
HOW TO—

Make Pipe-Wall Packing Gland

THE space around underground pipes at their entrance through the walls of basement-type pump rooms are often difficult to seal against the seepage of ground water. Water-tight seals are especially important in gasoline plants on the coastal plains during rainy seasons when drainage is difficult. Water leaking through inadequate packing spoils floor paint and the operator's efforts at plant housekeeping, makes walkways hazardous, and causes corrosion of exposed metal.

One type of packing glad used successfully on pipe seals through walls is illustrated in the photograph and inset sketch. It was made in the plant's shop.

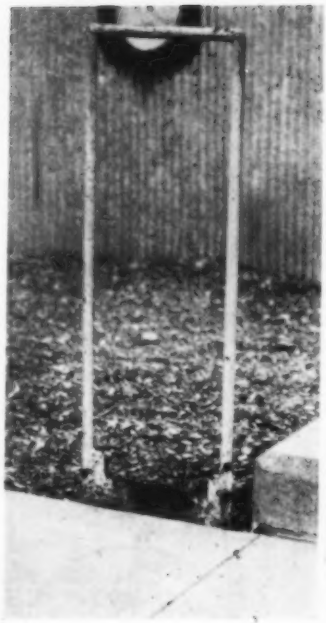
The two collars of heavy strap iron are made in halves and the two sections of each collar are bolted together as shown in the photograph. One collar is equipped with a sleeve, or packing gland, welded



Inset sketch shows bolt is used to tighten gland against packing in space between pipe and wall to prevent entrance of ground water.

to its inner edge, which enters the space between the wall and pipe to hold the packing in place. The other collar several inches behind the first, is equipped with adjusting screws in drilled and tapped holes spaced around its circumference. This collar is held in place on the pipe by setting-up the bolts connecting the two halves of the collar, then the adjusting screws are used to force the sleeve on the first collar against the packing in the space between wall and pipe.

By carefully packing the space between the pipe and wall and setting the packing gland properly, ground water seepage into the pump room is entirely stopped.



HOW TO—

Make Foot Scraper With "Hand Bars"

FOOT scrapers that men can use easily have hand bars attached to the blade and extending upward to a convenient height for grasping. These scrapers can be removed for sharpening or repair, as "foundation bolts" are set in the concrete walks when the cement is poured. The scraper fits in well with other safety devices for the prevention of injuries to men who could easily slip on a wet pavement if no supports were provided.

HOW TO—

Simplify Testing Exchanger Tubes

A SIMPLE method of testing exchanger tubes before installing them in tube bundles is being used in one refinery. One end of the tube is plugged with a solid rubber plug and the other end with a rubber plug having a hole for a ¼-inch tube, which is connected to a small pressure gauge and a compressed air supply. The compressed air is admitted to the tube until the gauge registers about 10 pounds. Then the air is shut off and the gauge checked to determine if the tube is air tight. If there are no leaks, the gauge pointer will be steady at 10 pounds pressure.

If the pressure falls off on the gauge, indicating a leak, water substituted for the air will show the location of the leak in the tube.

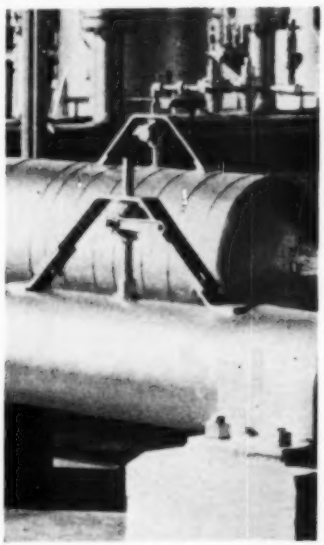
This method of testing is fast and efficient. It is espeically useful for check- a tube that is bent through which a cleaning tool will not pass.

HOW TO—

Protect Small Pipe Connections

THERE are numerous instances in process plants when small pipe connections, ranging in size from ¼ inch to ¾ inch, must be made through the wall of a larger pipe. In many cases, the larger pipe is a high pressure oil or gas line, and the connection is needed for sampling, pressure gauges, or regulators. The connection is made usually by welding one end of a threaded coupling to the hole drilled in the large line, then adding a short nipple for connection to a small valve.

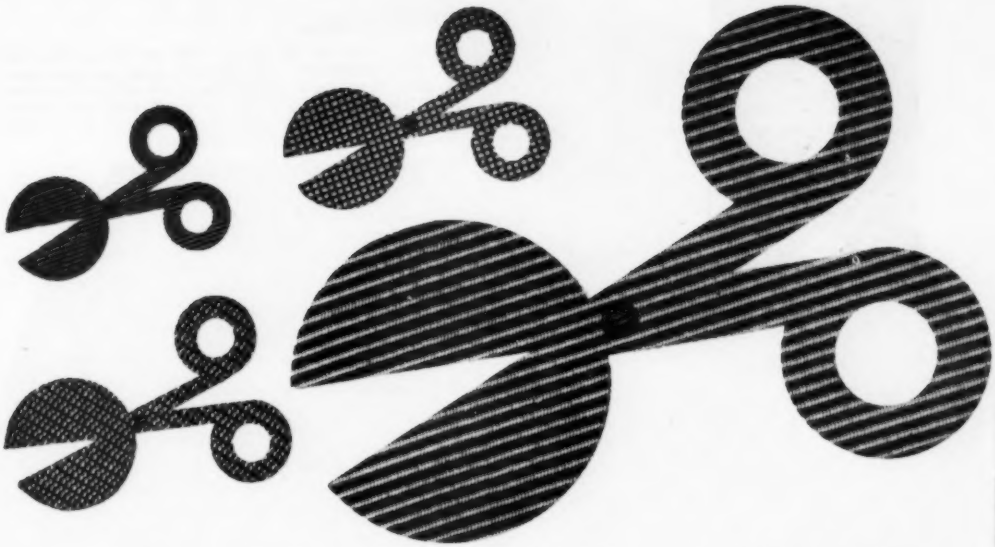
One of the hazards of such small fittings is the danger of breaking the short pipe nipple between the welded coupling



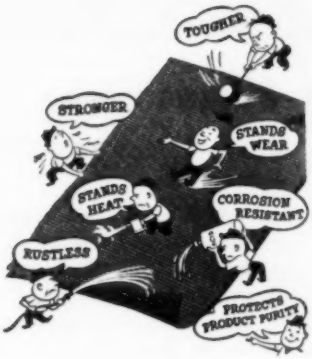
Photograph shows two small pipe connections to high pressure gas lines protected by heavy strap iron frames.

and the shutoff valve. Breakage occurs usually in a threaded section of the nipple.

The method of protecting the connection as shown in the photograph is employed in a South Texas cycling plant. The bracket is made of three pieces of two-inch by ¼-inch strap iron. The center section can be removed by means of the bolts fastening it to the lugs, which are welded to the pipe. A hole is drilled in the strap for the connection to the top side of the valve. Note that sufficient clearance has been provided for operation of the valve.



This Screen and Filter Cloth may help you cut costs!



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For this long-lasting wire cloth is not expensive. Its prices are comparable to what you are now paying for cloth of less durable metal. *Fine weaves of Monel and Nickel often cost less!*

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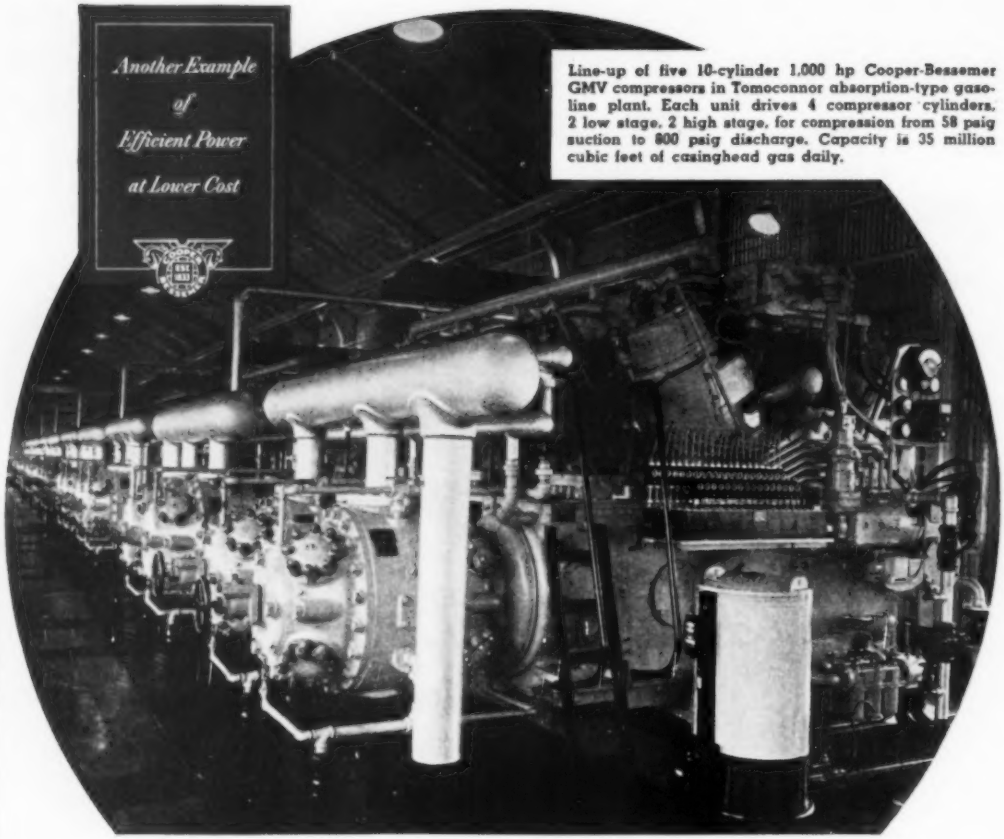
Another Example of Efficient Power at Lower Cost



Line-up of five 10-cylinder 1,000 hp Cooper-Bessemer GMV compressors in Tomoconnor absorption-type gasoline plant. Each unit drives 4 compressor cylinders, 2 low stage, 2 high stage, for compression from 58 psig suction to 800 psig discharge. Capacity is 35 million cubic feet of casinghead gas daily.

Line-up of GMVs at Tomoconnor helps line up profits in gas conservation

The Tomoconnor gasoline plant on the Texas Gulf coast is known for its high recovery of hydrocarbons and for unusual economy and efficiency of operation.

Naturally, compressor performance is a mighty important cog in the efficient, low-cost operation of this or any gasoline plant. Here, five 1,000 hp Cooper-Bessemer GMVs, as always, bring a number of significant advantages . . . exceptional compactness for cost savings in housing and installation, month after month of trouble-free, on-stream service, and the kind of over-all operating and maintenance economy that does your heart good.

We could go on and on about the features and advantages that are paying off in GMV-equipped plants. Maybe you have compressor needs coming up. If so, get *all* the facts . . . on GMVs or on our other modern V-angle type compressors . . . 200 to 2,400 bhp.

The **Cooper-Bessemer** *Corporation*

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New York City Washington, D. C. Bradford, Pa. Parkersburg, W. Va. San Francisco, Calif. Houston, Dallas, Greggton, Pampa and Odessa, Texas Seattle, Wash. Tulsa, Okla. Shreveport, La. St. Louis, Mo. Los Angeles, Calif. Caracas, Venezuela Gloucester, Mass. Calmes Engineering Co., New Orleans, La.

THE MONTH in the INDUSTRY

* * *

Magnolia Makes Changes In Natural Gas Setup

Magnolia Petroleum Company has made the following changes in its natural gas department:

John R. Ackenhausen transferred to district engineer of the Wewoka natural gas district. He was former plant foreman at Mamou, La.

William R. Stephens, former plant foreman at the Kenova, Ark., gasoline plant, transferred to the Mamou plant.

John E. Shannon, former field foreman at Mamou, transferred to the Hickok, Kan., gasoline plant.

Egloff Heads Engineers

Dr. Gustav Egloff, Universal Oil Products Company, has been elected president of the Western Society of Engineers. He has been a vice president and trustee of the society for the past five years and in 1940 received the Octave Chanute medal in recognition of his service in the engineering field. Graduating from Cornell University in 1912, he received his master degree from Columbia University in 1913 and his Ph.D. degree in 1916.

First Coal-to-Oil Demonstration Plant Is Dedicated by Government in Missouri

Dedication of the first coal-to-oil demonstration plant in the United States, being built and operated under direction of the Bureau of Mines, took place on May 8 near Louisiana, Mo. First completed units, costing $15 million of the $34 million plant, were those for oxygen and coal gasification to produce 2 million cubic feet daily of synthesis gas. The remaining units for converting the synthesis gas into oil and refining the oil into the various products, are expected to be completed later this year, according to the Bureau.

Speakers and officials present at the dedication ceremonies included Secretary of the Interior J. A. Krug; Representative (U.S.) Clarence Cannon of Missouri; Dr. Charles F. Kettering, director of General Motors Corporation; Gen. Brehon Somervell, president of Koppers Company, Inc.; J. P. Yates, vice-president of Bechtel Corporation; Dr. L. L. Hirst, chief of the Bureau's Coal to Oil Demonstration Branch; Dr. R. G. Dressler, chief of the Gas Synthesis Demonstration Plant; L. C. Skinner, supervising engineer of the Engineering and Design Section, and Dr. W. C. Schroeder, Chief, Office of Synthetic Liquid Fuels.

Highlight of the dedication was an address by Secretary of the Interior Krug, who advocated prompt construction of at least one or two commercial-size synthetic liquid fuels plants. Krug renewed his plea for early enactment of legislation authorizing Federal loans to build full scale plants, and said that this was the one tremendously important step remaining to be taken in the synthetics field to make certain that oil for the armed forces in time of war will be absolutely assured.

Krug said he would like to see the commercial-size plant dedicated next year, pointing out that without that final step in the program, the synthetic liquid fuels program is incomplete. "We have an industry in its infancy that needs to be developed on a commercial scale for use in any emergency threatening the existence of the nation," he declared. "With ample, known deposits of raw material, and the production process, all that is needed is the final step—drilling of the last hundred feet for the commercial-size plant." Krug said he was certain this one could be solved.

In his address, Krug denied that Federal loans to encourage construction of initial plants would amount to government competition with business.

Four Steps

The demonstration plant under construction at Louisiana under a contract with Koppers Company, Inc., will carry out the method of converting coal to oil in four steps on a scale intermediate between laboratory and commercial plant. The steps are 1) reaction of coal with oxygen and steam at 2000 to 2500° F. to produce a gas largely carbon monoxide and hydrogen, 2) removal of dust and injurious impurities, such as dust and sulfur compounds, and recovery of waste heat, 3) the synthesis step of passing the gas through a bed of catalyst at 400 to 600° F. and 300 to 600 psi. to cause the carbon monoxide to react with the hydrogen to produce

Calendar of Meetings

JUNE 12-16	Instrument Society of America, Annual Convention, St. Louis, Municipal Auditorium.
16-20	Canadian Gas Association, Annual Convention, Lake of Bays, Ontario, Canada, Bigwin Inn.
17-20	American Gas Association, Annual Convention, Chicago.
24-25	Michigan Gas Association, Annual Convention, Mackinac Island, Grand Hotel.
24-28	National Safety Council, Chicago, Morrison Hotel.
27-30	The American Society of Mechanical Engineers, Semi-Annual Meeting, San Francisco.
27 to July 1	American Society for Testing Materials, Annual Meeting, Atlantic City, Haddon Hall, Hotel Chalfont.
AUG. 17-31	United Nations Scientific Conference on Conservation and Utilization of Resources, Lake Success.
SEPT. 7-10	North American Gasoline Tax Conference, Lake Tahoe, Tahoe Tavern.
11-14	American Standards Association, Annual Meeting, New York, Waldorf-Astoria Hotel.
12-16	Instrument Society of America, National Conference and Exhibit, St. Louis, Municipal Auditorium.
14-15	American Petroleum Institute, Division of Marketing (Lubrication Committee) Atlantic City, Hotel Traymore.
14-16	National Petroleum Association, Atlantic City, Hotel Traymore.
18-20	American Institute of Chemical Engineers, Montreal, Canada, Mt. Royal Hotel.
SEPT. 19-21	National Butane-Propane Association, St. Louis.
24-28	National Safety Council, Chicago, Morrison Hotel.
28-30	The American Society of Mechanical Engineers, Fall Meeting, Erie.
OCT. 2- 5	American Society of Mechanical Engineers, Petroleum Division, 1949 Petroleum Mechanical Engineering Conference, Oklahoma City, Oklahoma, Biltmore Hotel.
3- 4	National Association of Corrosion Engineers, South Central Region, Dallas, Adolphus Hotel.
3- 5	National Lubricating Grease Institute, New Orleans, Hotel Roosevelt.
7	California Natural Gasoline Association, Los Angeles, Ambassador Hotel.
13-14	Texas Mid-Continent Oil and Gas Association, Annual Meeting, Houston, Rice Hotel.
17-20	American Gas Association, Annual Convention, Chicago.
31 to Nov. 4	National Safety Council Congress, Chicago, Morrison Hotel.
NOV. 1- 5	Pacific Chemical Exposition, San Francisco, Civic Auditorium.
7-10	American Petroleum Institute, 29th Annual Meeting, Chicago, Stevens Hotel.
7-10	American Institute of Chemical Engineers, Pittsburgh, Hotel William Penn.
27 to Dec. 2	American Society of Mechanical Engineers, Annual Meeting, New York, Hotel Statler.

On the Way to "BIGGER THINGS"

Reflux drum leaves our Birmingham Shop for Baton Rouge refinery

Shown leaving our Birmingham plant, this CB&I-built reflux drum was transported to Baton Rouge, La., where it went to work in one of the world's largest refineries—operated by Esso Standard Oil Company. The drum, which is 7 ft. 6 in. in diam. by 20 ft., is monel-clad for corrosion resistance. It is used as a reflux accumulator on an atmospheric pipe still and operates at a maximum pressure of 50 lbs. per sq. in. at 650° F.

Our complete design and fabrication facilities are producing a variety of similar "custom-made" steel plate equipment for the petroleum industry: special designs and metals, high pressure and high temperature ratings—all are a part of our regular working specifications. We'll be glad to give you quotations on steel plate vessels and field-erected steel storage tanks. Ask our nearest office for details.

CHICAGO BRIDGE & IRON COMPANY

Plants in **BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PENNSYLVANIA**

Atlanta 3	2146 Healey Building	Detroit 26	1520 Lafayette Building	Philadelphia 3	1608—1700 Walnut Street Building
Birmingham 1	1548 North Fiftieth Street	Havana	402 Abreu Building	Salt Lake City 1	1531 First Security Bank Building
Boston 10	1030—201 Devonshire Street	Houston 2	2126 National Standard Building	San Francisco 11	1251—22 Battery Street Building
Chicago 4	2463 McCormick Building	Los Angeles 14	1534 General Petroleum Building	Seattle 1	1331 Henry Building
Cleveland 15	2234 Guildhall Building	New York 6	3302—165 Broadway Building	Tulsa 3	1626 Hunt Building

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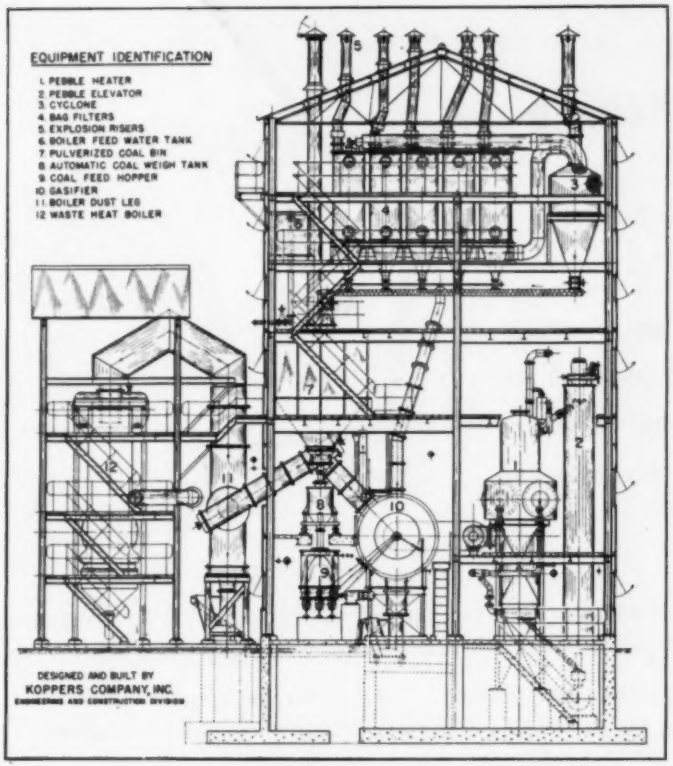

Above—Cross Section through the Gasifier Building, Louisiana, Mo., plant which was dedicated last month.

Right — The first train fueled by oil made from coal left St. Louis May 8. Examining the synthetic fuel are, left to right, James Boyd, director of the Bureau of Mines; Ralph Budd, president of the Burlington Railroad; and O. C. Moore, Burlington general foreman, St. Louis.

various liquid fuels, and 4) separation and refining of these fuels.

Raw coal for conversion in the plant is crushed, pulverized, and dried in equipment provided for the purpose in the plant. Oxygen for the process will be supplied by a Linde-Frankl plant, which was brought from Germany and installed at the plant site. The superheated steam required in the plant will be generated in a natural gas fired pebble heater.

Coal gasification is accomplished in a Koppers-type coal gasifier, in which coal suspended in oxygen and steam superheated to about 2500° F. are introduced into the reaction vessel. The unit will require about 28 tons of coal, 24 tons of oxygen, and 35 tons of superheated steam per day to produce its 2 million cubic feet of raw synthesis gas per day.

THE MONTH...

After the raw synthesis gas has been cooled and the fine particles of dust and ash removed, it is compressed to about 400 psi. Sulfur compounds and gum formers are then removed from the gas to prepare it for synthesis.

Mixed with recycle gas, the raw gas is passed up through a bed of granular catalyst, the internally cooled converter, which is a modification of the Fischer-Tropsch process. As conversion proceeds, the heat of reaction will be absorbed by a coolant oil, which will be circulated up through the bed, then through a boiler, where the heat will be used to generate steam.

Treatment of Liquids

The gases and product vapors from the converter are cooled to condense as much of the liquid products as possible and the uncondensed vapors will be recovered by oil absorption. Then the liquid products are treated in a distillation and refining section to separate various fractions. Certain of the fractions, such as gasoline, will be treated to improve the yield or quality.

Production of the demonstration plant is expected to be about 55 barrels of finished gasoline, 10 barrels of diesel oil, 12 barrels of heavy oils and waxes—suitable for cracking stock—and 5 to 10 barrels of propane.

The demonstration plant was built for research in the manufacture of synthetic fuels "as part of the program to assure the U. S. of sufficient oil reserves for the future." Among the important functions of the plant is testing and further development of equipment and processes; demonstration of the operation of a complete and integrated plant for coal-to-oil conversion; collection, analysis, and interpretation of operating data for development; study of the economics of the process for cost and investment for commercial operation; procurement of all possible information necessary to the design and operation of commercial plants; training personnel for a new industry, and reporting of all technical and economic information developed to industries and the public in general.

Low Cost Oxygen Process Tested by McCarthy Plant

A new process for producing low cost oxygen from air has been successfully tested commercially by McCarthy Chemical Company in its plant at Winnie, Texas. The plant is now producing in excess of 200 gross tons per day of 90 percent oxygen for the synthesis of methanol, formaldehyde and other petrochemicals.

One feature of the process is a low-pressure, self-contained cycle. The system requires no chemicals, using only cooling water and a source of fuel gas. Air is compressed to 85 pounds, cooled by expansion and self-refrigeration. The CO_2 and other impurities are removed by depositing them on special aluminum fintube exchangers. The oxygen is separated from the nitrogen in aluminum fractionating columns.

The process was perfected by Hydro-

a PERCO* unit does all

The 10,000 B/D Perco catalytic unit recently placed in operation by a large refiner, is easily switched to any of these operations:

1. **GASOLINE DESULFURIZATION – Boosts leaded octane of all the refinery straight run and cracked gasolines by 5 numbers with 99% yield.**
2. **STRAIGHT RUN GASOLINE REFORMING - Desulfurizes and reforms straight run gasoline to raise ASTM octane 8 points and Research octane 11 points with 97% yield.**
3. **GASOLINE REFORMING – GAS OIL VISBREAKING – Raises leaded octane of all straight run naphtha and a major portion of the cracked gasoline while visbreaking 25° to 30° API gas oil to obtain 70% of No. 2 distillate of –20° F pour point and 30% of No. 5 distillate.**
4. **GAS OIL CRACKING – Yields 75% gasoline of 80 ASTM 92 Research octanes with 3 cc. lead, 4% No. 5 fuel, 4% carbon, remainder gas when processing 27 to 30° API thermally cracked distillate at 1 to 1 recycle ratio.**

You can keep ahead in the octane race with a Koch engineered Perco unit. These low-cost units have been built in sizes ranging from 700 to 10,000 B/D. We'll be glad to give you our recommendations on a Perco unit to fit your requirements. Call or write us—no obligation.

* Licensed by Phillips Petroleum Co.

THE KOCH ENGINEERING COMPANY, INC.

DESIGNERS • MANUFACTURERS • BUILDERS
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carbon Research, Inc., and the unit for McCarthy was built by the Stacey-Dresser Engineering Division of Dresser Industries, Inc.

Jefferson Chemical Names Mitchell Chief Engineer

Harry M. Mitchell has been named chief engineer of Jefferson Chemical Company, Inc. Formerly assistant chief engineer of the company, he was employed by various petroleum and chemical industries before joining Jefferson on January 1, 1945. He succeeds G. R. Wick, who has been promoted to assistant to the production manager.

Mitchell

Jefferson completed its first plant at Port Neches, Texas, early in 1948. Products include ethylene glycol, ethylene oxide, ethylene dichloride and various other ethylene-derived chemicals. The company was formed in 1944 by The Texas Company and American Cyanamid Company.

Bolton Sent To Italy By New Jersey Standard

Ralph P. Bolton, of the producing coordination department of Standard Oil Company (New Jersey), has been appointed company representative for affiliates engaged in producing, refining and marketing operations in Italy.

Since 1944, he has headed the company's producing activities in the Eastern Hemisphere. He joined the company 27 years ago as a general field assistant for an affiliate in Roumania. Former executive posts include: manager of producing activities in Europe and North Africa, general manager and managing director of the Roumanian affiliate and general manager of all company affiliates in Argentina.

Changes By Stanolind In Three Of Its Areas

Stanolind Oil & Gas Company changes in three of its divisions include:

E. A. Renfro to become gas superintendent for the Texas-Louisiana Gulf Coast division. He will be responsible for the technical phase of the operation of Stanolind's natural gasoline, cycling and pressure maintenance plants as well as for the sale of their products. Former division sales superintendent at Houston, he has been with Stanolind since 1934 and is a graduate of the Colorado School of Mines.

F. F. Diwoky named gas superintendent of the central division with similar duties. Holding bachelor of science, master of science and Ph.D. degrees from Oregon State College, Iowa State College and the University of Wisconsin, respectively, he was formerly project engineer in the manufacturing department in Tulsa.

G. F. Moore appointed gas superintendent of the Rocky Mountain division with similar duties. Before his new appointment, he was in the manufacturing department in Tulsa. He has a degree from the University of Delaware.

UOP New Process Termed Autothermic Cracking

A new process likely to prove valuable to gas companies and to the petrochemical industry, has been developed by Universal Oil Products Company, Chicago, and is ready for commercialization.

For gas companies, the new process, named Autothermic cracking, will reform propane or other volatile hydrocarbons in admixture with air to make supplementary gas to meet emergency peak load demands.

For petrochemical manufacturers it will crack ethane, or other economically available volatile stock, converting it to ethylene, the starting material for the manufacture of alcohol, antifreeze mixtures and many other products.

R. M. Deanesly, UOP research chemical engineer, started with the basic idea of conducting cracking reactions by admixing air with the charge stock rather than by external heating, and has developed techniques resulting in a compact, low cost gasification process of exceptional simplicity, in which dilution of the gas with nitrogen is reduced to a minimum, thus greatly improving the quality of the gas.

The mechanism of the process consists of preheating separately the air and hydrocarbon streams, mixing while hot, and reacting in a small insulated vessel. The hydrocarbon-air mixture is rapidly converted to reformed gas and nitrogen. The hot gases leaving the reactor are cooled by heat exchange. Heat losses are almost negligible, the overall thermal efficiency of the process being better than 98 percent.

The Autothermic process has been tested and proved in pilot plant operations producing 1000-2000 cubic feet of gas per hour, and thorough burner tests on the gas have been conducted by engineers of large gas companies.

Changes Made At Martinez Refinery By Shell Oil

Staff changes and promotions at the Martinez, Calif. refinery of Shell Oil Company include:

John M. Brackenbury, assistant superintendent of the refinery, has been appointed superintendent of the Montreal, Quebec, Canada refinery of Shell Company of Canada, Ltd., effective June 16. He joined Shell as a laboratory inspector at the Wilmington, Calif. refinery in 1933. In 1945 he became chief technologist at Martinez and assistant superintendent in 1946.

Leonard T. Wilson promoted to assistant refinery superintendent, succeeding Brackenbury. He formerly was department manager of catalytic cracking at the Dominguez, Calif. refinery. He joined Shell in 1933 as a laboratory inspector.

J. D. Davis succeeds Wilson as manager of the catalytic cracking department. Prior to his appointment he was manager of the gauging department. He came to Shell in 1934 as a laborer.

F. S. Hummel, former assistant department manager of the refining department, succeeds Davis as manager of the gauging department. He was first employed by Shell in 1936 as a chemist.

Foster Snell Picks Three

Foster D. Snell, Inc., has elected L. C. Cartwright secretary; Albert F. Guiteras, treasurer; and Louis J. Bowlby, Jr., assistant treasurer.

Cartwright received his bachelor of science degree in chemical engineering from the University of Florida and his master degree from Harvard University. He will continue as account executive of the firm. Dr. Guiteras graduated from Lafayette College with a bachelor of science degree and from the Goettingen University in Germany with a Ph.D. He also is director of bacteriology and toxicology. Bowlby joined the accounting department of Foster Snell in 1947.

THE MONTH...

Gulf Names Vice President, General Refinery Manager

Sullivan

Barnes

Thomas J. Sullivan has been elected vice president in charge of manufacturing for Gulf Oil Corporation and Bonnar H. Barnes has been made general manager of refineries.

First employed as foreman of the acid plant at the Port Arthur, Texas, refinery in 1921, Sullivan later became assistant general superintendent. In 1935 he was made general superintendent of Texas refineries. Transferred to Pittsburgh in 1939, Sullivan was made assistant general manager of the manufacturing department and in 1940 he became general manager.

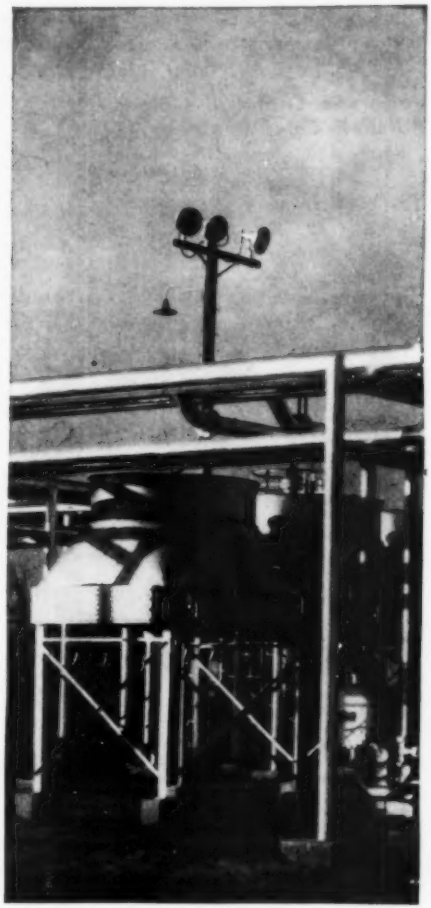
Barnes joined Gulf as a chemist in 1921, was promoted in 1929 to superintendent of the Sweetwater, Texas, refinery, and later superintendent of the Toledo, Ohio, refinery. Returning to Port Arthur as assistant general superintendent in 1935, he was promoted to general superintendent of the Texas refineries in 1939. In 1945 he was transferred to Pittsburgh as assistant general manager of the manufacturing department. During the war he was assistant director of refining in charge of refining operators and technical processes for the Petroleum Administration for War.

Deep Rock Picks Carthaus As Head Of Manufacturing

William J. Carthaus has been elected vice president of Deep Rock Oil Corporation, succeeding Wilford E. Moody, who retired June 1. He will be in charge of manufacturing and research, with headquarters at Tulsa.

Joining the company in 1929 as manager of naphtha and specialty sales, Carthaus became assistant to the general sales manager in 1933 and general sales manager in Chicago in 1938. In 1948 he was promoted to assistant to the president. Previous employers were Cities

6 Tough Cooling Duties in 1 Plant Handled by 1 Model ALCO Exchanger



The Skelly Oil Company gas plant at Velma, Oklahoma, built by the Born Engineering Company of Tulsa, presented a unique problem in certain process cooling requirements. Six different cooling jobs had to be handled in one battery, calling for different heat loads, temperature ranges and operating pressures.

One Alco air-cooled heat exchanger model (the uni-bundle*) was selected to handle all these cooling duties. The customer advises, "Units are operating successfully at over-design capacity." A fine example of how Alco *standardized* air-cooled exchangers can be tailored to suit customer needs—simplifying operation, maintenance, replacement of parts. Alco's *standardized* models bring low cost per year of operation and multiple savings in upkeep costs.

*Trademark patented

ARE YOU FACED WITH ANY OF THESE COOLING PROBLEMS?

- Insufficient water supply
- Scale from bad or brackish water
- Expensive water treatment
- Difficult waste water disposal
- High pumping costs
- High relative humidity
- Excessive space requirements for cooling basins

THEY CAN BE SOLVED INEXPENSIVELY BY ALCO AIR-COOLED EXCHANGERS

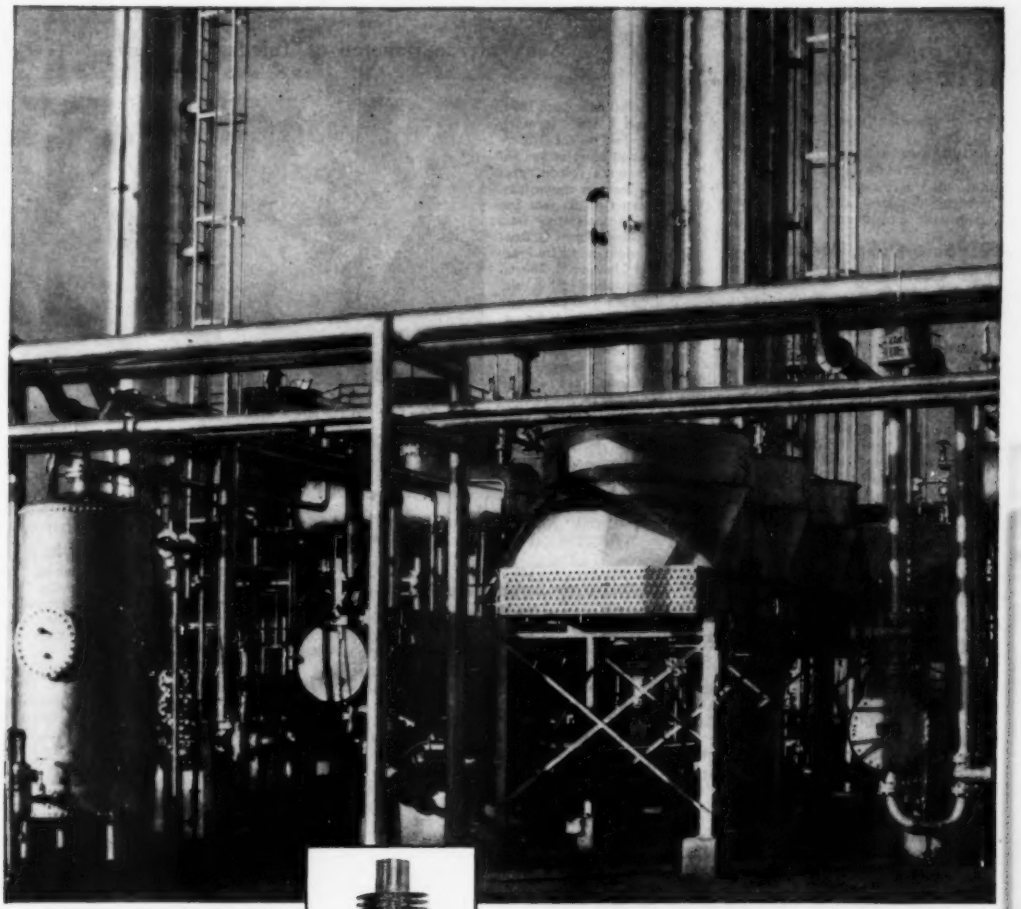
Proved in use in many of the nation's largest gas plants, in pump line stations, in power stations, in diesel locomotives—in many varied applications—Alco exchangers may be the answer to your specific problem.

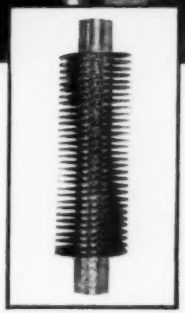
ADVANTAGES OF ALCO DESIGN

1. Volume production means standardized parts, easy maintenance, low cost per year of operation.
2. Simple field installation of standardized components.
3. Fans may be driven by any form of power.
4. Natural draft construction increases efficiency, reduces power requirements. Sometimes this natural draft is sufficient to produce adequate cooling without use of fans.
5. Wind direction and velocity do not affect efficiency.
6. Cooling surfaces positioned to minimize damage from wind-driven sand, rain, hail.
7. Induced draft insures uniform distribution of air across cooling surfaces.

FIN-TUBE MODELS CAN PERFORM MULTIPLE DUTIES

Selection of type of cooling surface to be used should be determined by economics and process requirements. As manufacturers of both radiator core and fin-tube types, and also as one of the world's largest makers of heat exchangers, Alco is in a position to give impartial advice.





Quality controls of Alco fin-tube manufacture assure highest heat dissipation rate. Fins wound on under pressure and permanently bonded on tube by means of solder bath completely covering fin and tube. Easy to handle, easy to clean with compressed air.

ADDITIONAL ADVANTAGES OF FIN-TUBE MODEL

1. Separate surfaces for separate cooling duties can be mounted in the same unit.
2. Header design permits variation of passes to suit process requirements of a given job, thus allowing selection of minimum surface within pressure drop limitation of the process while maintaining maximum velocity required for highest rate of heat transfer.
3. Orifices built into manifold-header design assure uniform distribution to entire cooling surface.
4. Bundle design of Alco fin-tube construction eliminates air leaks.

WRITE FOR FREE BOOKLET, just off the press, containing engineering, design, and selection data on Alco air-cooled heat exchangers. Learn how Alco can help you.

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AMERICAN LOCOMOTIVE CO., Dept. H, Dunkirk, N. Y.

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☐ Have an Alco representative call, at no obligation to me.

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Company .....

Title .....

Address .....

THE MONTH . . .

Service Oil Company and Shell Oil Company.

A 1920 graduate of the University of Illinois, Carthaus is a member of the American Petroleum Institute, American Chemical Society and the Society of Automotive Engineers.

UN Scientific Meeting Will Convene In August

The United Nations Scientific Conference on the Conservation and Utilization of Resources, scheduled for August 17-September 6, 1949, is to be devoted to an exchange of ideas and experience on the techniques of resource conservation and utilization, their economic costs and benefits and their inter-relations.

During the first part of the program, the conference will examine the state of the potential resources of the world, measure its depletion and review its existing critical shortages. The development of new resources by applied technology will also be discussed. The second half of the program will consist of section meetings where specialists can exchange methods and experience regarding specific problems and techniques.

Ashland Official Tells Of Oil's Role in Change

Oil men were termed "revolutionists", along with other independent American business men by W. W. Vandeveer, Ashland Oil & Refining Company director, who spoke last month in Tulsa.

He said this revolution had been going on for more than 150 years and during the last 90 years the oil industry had been among the leaders, people's lives having been changed radically since the discovery of the Drake well in 1859.

"Had America been a dictatorship, Washington in the early 20's would have met the gasoline supply crisis by curtailing automobile production and rationing the fuel," Vandeveer declared. "They could have done it in no other way."

Better Oil Storage for Military Sought in Bill

In an effort to correct deficiencies in petroleum storage for the armed forces and to provide storage needed to build stocks to desired operational levels in the United States and elsewhere, identical bills have been introduced in both branches of Congress. Authorization of in excess of $50 million to finance "additional capacity and allow military to run several million barrels extra of products, principally aviation gasoline, to storage," has been proposed.

Defense Secretary Johnson describes the legislation "the minimum requirement for authorizations which are immediately necessary and critical in the light of the over-all strategic considerations of the services."

Supertanker Launched

The SS Esso Cristobal, the fifth supertanker in the fleet of Standard Oil Company (New Jersey), was recently launched at Newport News, Va. With a speed of more than 16 knots, the 12,500-hp. vessel is powered by General Electric geared turbines. The cargo tank has a volumetric capacity of 230,000 barrels of oil.

Sun Veteran Honored at Toledo Ceremony

An oil man since 1894, Albert E. Daily (center), operator in the water-treating plant at Sun Oil Company's Toledo refinery, receives congratulations on his 55-year Sun service anniversary from President Robert G. Dunlop, right, and Vice President Clarence H. Thayer. Presentation of a six-diamond gold emblem to Daily in honor of his unusual record was a highlight of the fifth annual reunion of Sun's Toledo area employees recently. He is the second to complete 55 years of service with Sun. The first was the late J. Edgar Pew, who passed the 55-year mark in 1946.

Daily started his Sun Oil career in May, 1894, at Prairie Depert, now Wayne, Ohio, when he was 17 years old. He lives in Portage, Ohio, and drives the 52-mile round trip to his work in the Toledo plant.

Dunaway Succeeds Jones As Texaco Refining Agent

E. O. Dunaway has been named department agent of the refining department of The Texas Company to succeed F. C. Jones who is retiring after 39 years of service with Texaco.

Jones, a native of Kansas, where he started his oil career, has been Texaco's refining department agent for the past 20 years. He joined The Texas Company at Houston in 1910.

Dunaway, who steps up from his post as assistant agent for the refining department, has been a Texaco employe for 27 years, with the exception of an interim year spent with another company. After serving in various accounting and auditing capacities in Houston, commencing in 1922, he was transferred to the managerial offices of Texaco's Refining Department in New York. During World War II, Dunaway assisted in the important work of negotiating and administering war contracts and contract settlements.

In October, 1945, he was made assistant to management, foreign operations, and in November, 1946, was named assistant department agent of Texaco's refining department.

Chemical Industry Trends Offered in College Course

The department of chemical engineering of the University of Colorado is offering a new course, "Trends in the Chemical Industries," during the summer quarter from June 16 to August 26, 1949. Representatives of the chemical and process industries will conduct the courses. Each representative will discuss the current and predictable problems in his particular industry.

Companies taking part in the program include American Cyanamid Company, Calco Chemical Division, Bound Brook, N. J.; Carbide and Carbon Chemicals Corporation, South Charleston, W. Va.; and Monsanto Chemical Company.

Struth Joins Information Staff of API in New York

H. J. Struth, veteran oil economist and analyst, has been appointed assistant director of the department of information of the American Petroleum Institute, succeeding Robert E. Allen, who resigned effective May 31.

Struth joined the Institute staff last January, coming to New York from Dallas, where he originated and edited the first two editions of the "Petroleum Data Book" for the Petroleum Engineer Publishing Company.

Struth has been in the oil business for 30 years and has authored many papers on oil economics.

In his new position, Struth will work under H. B. Miler, director of the department of information, and will serve as his administrative aide in the functioning of the department.

LP Gas Association Elects Si G. Darling President

President of the Liquefied Petroleum Gas Association for 1949 is Si G. Darling, president of Darlingas, Inc. A director of the association for several years, he recently served as chairman of the publicity and advertising committee. He is a past president of the Kansas Liquefied Petroleum Gas Association.

Other officers are Edward C. McEneany, Diablo Company, first vice president; W. S. Lander, Ruland Gas Company, second vice president; Walter Miller, Dri-Gas Corporation, treasurer; Howard D. White, Chicago, executive vice president; Frank Fetherston, New York, vice president in charge of the technical division; and Arthur C. Kreutzer, Chicago, secretary.

More Army Reserve Units Organized by Sun Company

Six additional Army organized reserve units have been activated as a part of the Army affiliation program of Sun Oil Company. Sun sponsored units now total ten, including a unit at the Toledo, Ohio, refinery.

The new units will engage in intelligence training. Units include strategic intelligence team, military intelligence

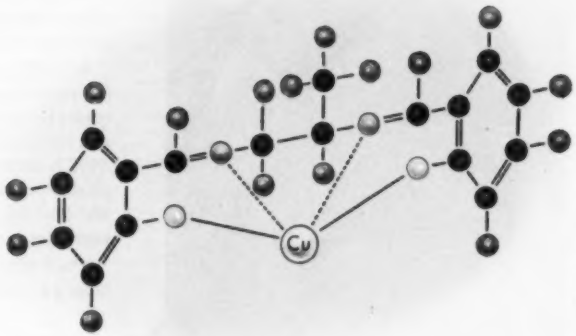
To *Improve Gasoline Storage Stability*
use Du Pont METAL DEACTIVATOR

The Most Economical Additive for Controlling Copper Activity

Copper, when present in gasoline, has a decided pro-oxidant effect. It may be difficult to tell when copper is the cause of trouble because traces of dissolved copper picked up from brass condenser tubes, pump parts, valves and fittings are sometimes hard to detect by ordinary analytical methods. Yet even one part in several million parts of gasoline can cause a pronounced increase in oxidation.

In gasoline containing copper, the storage stability will be improved by adding Du Pont Metal Deactivator. This additive is highly effective, easy to handle, and the Deactivator response may be readily evaluated by induction period tests. The use of Du Pont Metal Deactivator may result in real savings because in every case overcoming the catalytic effect of copper is more economical with Metal Deactivator than an attempt at stabilization with antioxidants alone.

Ask your Du Pont Petroleum Chemicals Representative about Metal Deactivator, or write the nearest District Office for specific information.



Du Pont Metal Deactivator

(N:N^1-disalicylidene 1:2-diaminopropane) combines with dissolved copper to form a stable chelate as shown here. Chelate is inactive and has no pro-oxidant effect on gasoline.

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that stay on the job

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(a patented alloy)

Chase Antimonial Admiralty has been in use for 14 years, withstanding the test of time — *because* the percentage of antimony is *right*.

Admiralty containing less than .007% antimony (the minimum set forth in Chase Patent No. 2,061,921) cannot be counted on to prevent dezincification under all conditions. Over a wide range of applications, .015% is the minimum. Chase makes doubly sure you get this percentage—by using a nominal content of .035%, so that even with normal commercial variation your tubes contain at least .015% antimony.

That's why Chase patented Antimonial Admiralty tubes stay on the job, year after year. Get the facts!

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platoon, interpreter detachment, order of battle detachment, interrogator detachment and aerial photo interpretation detachment.

Dr. W. A. Bain Is Kellex Chemical Research Director

New director of chemical research for The Kellex Corporation, subsidiary of The M. W. Kellogg Company, is Dr. W. A. Bain. Since 1947 he has been assistant to the technical director.

Bain

Dividing his career between industrial engineering and higher education, Dr. Bain was successively a member of the faculty of the North Carolina State University and the University of Wisconsin. Entering industry, he was senior chemical engineer for a large chemical company for four years and headed the engineering department of the research laboratory.

Dr. Milton H. Fies Named Bureau of Mines Consultant

Dr. Milton H. Fies has been named a consulting engineer to the office of synthetic liquid fuels of the Bureau of Mines. He will continue as part time manager of coal operations for Alabama Power Company. The company is now collaborating with the Bureau in a second field-scale experiment in the underground gasification of coal at Gorgas, Ala.

A graduate of the School of Mines of Columbia University, Dr. Fies has been associated with Republic Iron & Steel Company, Birmingham Coal & Iron Company (now Woodward Iron Company), DeBardeleben Coal Corporation and has been a private consulting engineer.

Atlantic Adds Executives To Board and Management

Dwight T. Cooley and P. G. Wharton, vice president, have been added to the board of directors of The Atlantic Refining Company.

The board elected Henderson Supplee, Jr., former director and vice president, to the newly created post of executive vice president; Hugh W. Field, former board member and manager of the research and development department, to vice president; and Dwight Colley to vice president and general manager of domestic sales.

Engineering Office Opens

Wyatt C. Hedrick Engineering Corporation has opened offices in Houston with G. M. McGranahan as head of the firm. The company will specialize in the planning and construction of plants for the petroleum, natural gas, chemical and allied industries. McGranahan was formerly assistant general manager of Dow Chemical Company's Texas division and more recently vice president and general manager of McCarthy Chemical Company.

Alcohol for Motor Use Is Suggested By Hilbert

The use of industrial alcohol from farm products "would result in a large saving of lead and petroleum through blending of the alcohol with gasoline or by use of an injection device on motor vehicles," Dr. G. E. Hilbert, chief of the Federal Bureau of Agricultural and Industrial Chemistry, told a Senate agriculture subcommittee studying the possibility of using farm-products alcohol in motor fuel.

For ordinary light-load car operation, on level ground at a reasonable speed, "a low octane gasoline will serve adequately 95 percent of the time," he estimated. It has become the practice to use high octane gasoline to keep the engine from "knocking" when accelerating the automobile or in climbing hills, but the use of an alcohol injection would permit extra antiknock value to be applied to the engine at the time needed and would allow the use of a low octane gasoline during the rest of the time, he explained. Experiments have shown that about one gallon of alcohol would be required for every 50-60 gallons of gasoline used for average driving.

The trend toward the use of increasingly higher compression ratios in new engines has also raised the question as to the ability of the refining industry to supply required quantities of suitable fuels, he pointed out.

Railroad Use of Diesels Continues Upward Trend

Ownership of diesel-electric locomotives in 1948 has maintained the upward trend of recent years, and steam locomotive ownership has declined, according to "Review of Railway Operations in 1948," issued by the Association of American Railroads.

Steam locomotives numbered 32,613 at the end of 1948 with 86 installed during the year, and 72 ordered. Diesel-electric locomotives numbered 5640. During the year 1397 were installed, and at the end of the year 1561 were on order. The report showed ownership of only 728 electric locomotives, four of which were installed during the year, and none on order at the end of the year.

The association reported that ownership of steam locomotives also decreased by 6544 units since 1942. Ownership of diesel-electric and electric locomotives increased 4061 units over 1942.

The value of the fuel oil consumed by the locomotives in 1948 increased almost 52 percent over 1947 compared with an increase in the dollar value of coal of about 6 percent. The total value of residual and diesel fuel used in 1947 was $117,983,000 and $203,927,000, respectively. Gasoline used by the railroads for fuel was $8,969,000. Cost of lubricating oils and grease, illuminating oils, boiler compound, and waste increased to $42,754,000 in 1948 over $35,712,000 in 1947.

IPAA Reduces Estimate For Summer Oil Demand

The estimate in total petroleum demand for the 1949 summer period, from April 1 to September 30, has been reduced 3.5 percent by the supply and demand committee of the Independent

THE MONTH...

Petroleum Association of America. Demand, including exports, has been revised to an average 6,210,000 barrels daily during the period.

Although a downward revision from prior estimates, the total is an increase of 4 percent over actual consumption during the same months last year. The new figure represents a 1.5 percent decrease from the amount estimated in December, 1948, by the economics advisory committee of the Interstate Oil Compact Commission.

Oil Companies Showing A Decline In Earnings

Earnings of 16 of the 20 major oil companies declined an average of 17.7 percent during the first three months of 1949 as compared with the first quarter of 1948. Competition, which has caused prices for all major products except gasoline to decrease, is claimed to be responsible.

The only companies to show an increase were The Texas Company with three percent and Standard Oil Company of California with one percent. Declines ranged from six percent for The Atlantic Refining Company and Union Oil Company of California to 52 percent for Mid-Continent Oil Company.

A group of 13 smaller companies showed an average decline of 12 percent in earnings. Three companies showed increases ranging from 4-32 percent. Decreases ranged from 8-44 percent.

Crude-Buying Refiners In Tight Spot, Survey Says

Declining demand for residual fuel and low refined product prices are forcing crude-buying refiners out of business because "operation costs prevent him from breaking even," a study of refinery operations recently completed by the Western Petroleum Refiners Association shows.

A survey was made of product yields, operating costs and realizations during March of Kansas, Oklahoma and North Texas plants with 4000-8000 barrels daily capacity, skimming and thermal cracking. "Increasing cost of materials and labor in the postwar years have added 65 percent to the operating cost since 1945," the survey pointed out.

Standard Board Chairman Given Government Award

W. T. Holliday, board chairman of Standard Oil Company (Ohio), has been awarded the 1948 World Government News award for an individual. Active in organized efforts toward world government, he is vice president of United World Federalists. His treatise, "Our Number One Job: World Peace," has been distributed, in original, digested and abridged form, in more than 30 countries.

Aviation Gasoline Prices Too High, Hellman Charges

The high price of aviation gasoline used by civilian airlines is "shameful," a government aviation economist charged last month and the oil companies should

Applying foresight to problems of engine operation

Ethyl predicts the performance of fuels and lubricants used in engines operating in field service. This foresight is the foundation of Ethyl's "preventive service" designed to help refiners meet, with a minimum number of fuels and crankcase lubricants, the continually expanding use of gasoline engines, under a wider range of operating conditions.

Ethyl's "preventive service" is aimed at avoiding difficulties which might otherwise arise in the use of petroleum products. Frequently, before experimental engines are put into production, the Laboratories subject them to exhaustive tests. If any incompatibility with petroleum products appears, modifications are made until successful results are achieved. Information so obtained is passed along to the engine manufacturers. All the wide variety of Ethyl's varied research facilities, including a cold room (left), are available for such work.

As a result of experience gained over more than 26 years, Ethyl Laboratories are able to evaluate the properties of petroleum products in respect to the results they may be expected to give in the wide variety of gasoline engines now in production. The performance of many types of gasolines and lubricating oils, under a wide range of conditions, is continuously observed in research projects at the laboratories. If any incompatibility of these products with engines in production is noticed, the results are passed along to the oil companies.

Many members of the Ethyl Laboratories are authorities on engine-fuel relationships and are always available to engineers of automotive companies for consultation in connection with research programs conducted in their own laboratories. Likewise, Ethyl technologists are glad to discuss with technical people of oil companies the performance of their products as revealed in research programs and in field service.

Occasionally operating problems develop in the field because of abnormal conditions which could not be anticipated during the design of the engines. When this happens, the Ethyl Laboratories, having the benefit of specific information supplied by its field organization, work closely with the oil and automotive companies concerned.

A further extension of Ethyl's work in the field is the maintenance of contact with the operators of truck, bus and passenger car fleets. Based on field observations and on special research work conducted in the Ethyl Laboratories, recommendations are made to engine users to assist them in obtaining the best engine performance and durability on the fuels and crankcase lubricants used.

Ethyl's field and laboratory consulting service is part of the comprehensive Ethyl program aimed at:

1. Providing antiknock compounds of the highest quality.
2. Assisting refiners to use "Ethyl" antiknock compounds most effectively.
3. Helping the makers and users of gasoline engines to get the greatest benefit from gasoline improved with "Ethyl" antiknock compound.
4. Assisting refiners in their future plans by anticipating developments in automotive power plants and fuels.

This message is the fifteenth in a series dealing with problems faced by refiners in producing gasoline for today's and tomorrow's engines, and the contribution of the Ethyl Corporation to their solution. Future messages will discuss other phases of these complex problems.

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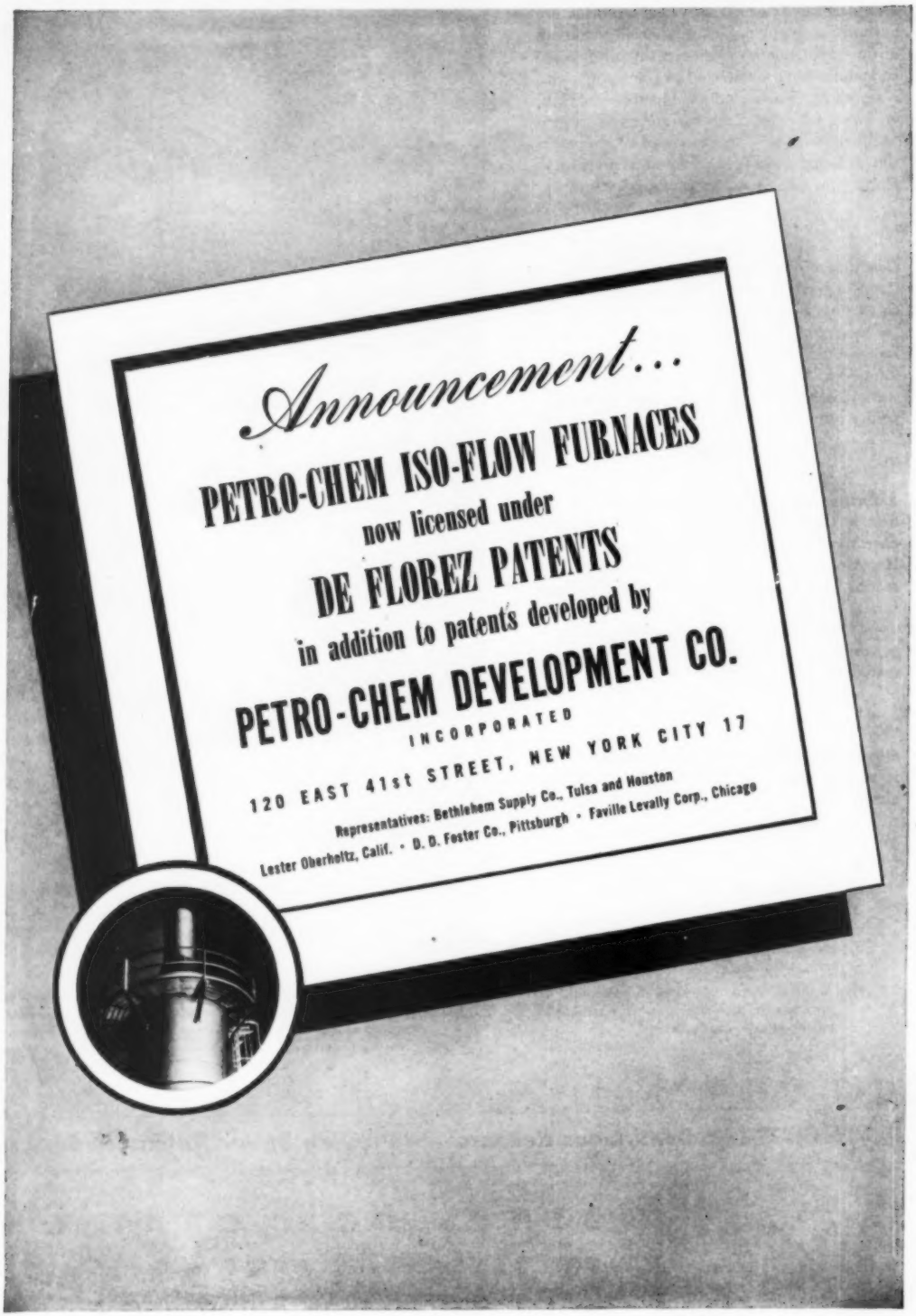
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be summoned before Congress for an accounting.

Richard Hellman, Federal Power Commission economist, who was loaned to Reconstruction Finance Corporation to make a study of airline financing, told a Senate Commerce Subcommittee that high priced gasoline was one of three problems facing domestic airlines.

Hellman declared that gasoline prices are still nearly as high as any time in history, despite lower crude oil prices. He said he estimated on the basis of gasoline consumption in 1948, that for every cent the price of gasoline is reduced, airlines would save $3.5 million. million.

Work Starts on Fawley Plant of Anglo-American

A big contribution to Great Britain's program for increasing the United Kingdom's refining capacity will result from construction work which has started on Anglo-American Oil Company's refinery at Fawley, England. Capacity is to be increased to 110,000 barrels daily. Present output is 18,000 barrels daily and cost of increasing the output is estimated at $150 million. Three years will be required to complete the expansion project.

THE MONTH . . .

Problem of Petroleum Imports Brings Forth Various and Vigorous Opinions

The choice rests with Congress as to whether this country shall have a virile oil producing industry or whether the domestic industry shall "shrivel on the vine under the withering sun of possible foreign competition," Ernest O. Thompson, of the Texas Railroad Commission, said in testifying before the House Small Business (Patman) Committee recently.

The deluge of foreign oil imports is jeopardizing national security, Thompson said. If a flood of foreign oil is permitted, independent producers cannot continue to search for new fields upon which national security depends, he declared. Crude oil imports were 33 percent greater in 1948 than in the preceding year and have been steadily increasing. He said the industry probably could absorb, without damaging effect, the 326,000 barrels per day of imported oil that 14 companies plan to import during June.

Thompson claimed that reductions in Texas' allowables of more than 825,000 barrels since the first of the year have been almost a direct result of the deluge of foreign oil. He suggested that a law be passed empowering the Department of Commerce to prorate on a quota basis, so that foreign oil would only supplement domestic production.

Low Oil Estimates

Wallace E. Pratt, retired Jersey Standard vice president, told the committee that a world-wide oversupply of oil is the No. 1 problem facing the American petroleum industry. He said that previous estimates of the world's untapped oil resources have been way low, predicting this country should ultimately give up at least a hundred billion barrels of oil and set the world supplies at some six hundred billion barrels. Pratt declared that a thriving domestic oil industry is this nation's first line of defense and recommended that Congress take action to assure full development.

A number of independent operators testified that increasing oil imports are drastically cutting their profits, which is resulting in a decline in drilling and idling of rigs and a consequent unemployment of workers.

Monroe Chaney, Coleman, Texas, geologist, said that reductions in allowables threatens to lower reserve levels below that healthy for national defense. He and other witnesses testified that the cutback in Texas allowables was caused by foreign oil imports.

J. P. Coleman, independent oil man, Wichita Falls, Texas, urged a quota system.

Hallanan's Views

Walter S. Hallanan, president of Plymouth Oil Company, Pittsburgh, told his stockholders on May 16 that "we must restrict the current high level of imports or look to further expansion of domestic demand for petroleum products," this because of expanding production and contracting markets. Development of Middle East oil fields has destroyed the American oil market in Europe and discoveries in Canada have weakened that market, he pointed out.

Discussing prices, Hallanan explained the free price system of the industry as one where higher prices bring about lower prices to the consumer. "The higher prices encourage exploration and development to the extent of bringing about large increases in supplies. At the same time they have the effect of reducing consumption. With supplies increased and demand decreases, prices get lower," he said.

Month's Developments

Other developments during May centering about the topic of oil imports included:

Economics Advisory Committee of Interstate Oil Compact Commission declared: "Imports, which had been increased sharply last year to supplement domestic supplies, have been declining, but in the first four months were higher than a year ago by 76,000 barrels daily. Total supply in this period was 37,000 barrels daily less than a year ago."

Harris (House of Representatives) Committee told by Acting OGD Director Friedman that complex questions are involved and he cautioned close study before any tinkering (with oil imports) is attempted. He is said to have painted Canadian oil developments as approaching the sensational.

Senator Thomas of Oklahoma introduced a bill which would limit imports to 5 percent of domestic consumption during the corresponding quarter of the previous year. It was offered as an amendment to the bill extending reciprocal trade agreements.

J. Howard Marshall, president, Ashland Oil & Refining Company, said present conditions indicate a middle course in the controversy as to imports vs. domestic production. "Cut back domestic production sufficiently to build anew some reserve capacity for future wars and import enough oil to make this possible," he said.

Russell B. Brown, general counsel of IPAA said late in the month that all indications are that "importing companies cannot be expected to settle the problem of excessive imports of foreign oil" and that "only legislative action will provide the reasonable assurance that domestic independent producers need" that they can continue in the business. "Continued saturation of our domestic market with fuel oil and heavy crudes by the importing companies will drive out of competition the small refiners dependent upon domestic crudes or drive out of competition the domestic producer," Marshall said. "In either case the part of the importing companies in the domestic oil industry is enlarged and the trend toward monopoly is accelerated."

Jack McKay Will Handle Fluor Public Relations

Fluor Corporation, Ltd., designers, engineers and constructors for the petroleum, chemical and power industries, has appointed Jack E. McKay manager of advertising and public relations. McKay assumes this new position following three years as assistant to J. P. Wiseman, vice president and director of sales for the corporation.

McKay

Prior to joining Fluor in 1942, McKay was associated with The Carter Oil Company in Tulsa and Sinclair Refining Company in Sand Springs, Okla.

S. J. Gardner Joins Husky

S. J. Gardner has joined Husky Refining Company as traffic manager. He was traffic manager for Western Oil & Fuel Company from 1927 to 1947 and prior to that was engaged in freight and traffic work for the Milwaukee railroad. He is a graduate of the University of Minnesota.

ASTM Area Meet

The field of engineering materials and related subjects will be discussed in some 70 technical papers at the first Pacific area national meeting of the American Society for Testing Materials to be held in San Francisco at the Hotel Fairmont during the week of October 10, 1949. An all-day engineering and inspection trip is scheduled during the meeting.

Annual ASTM Meet

Twenty-two technical sessions as well as informal sessions and round-table discussions are scheduled for the 52nd annual meeting of the American Society

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for Testing Materials at Atlantic City, N. J., during the week of June 27. Technical committees will perfect and complete work on specifications and tests now under way and initiate new research and standardization work.

For the first time 50-year members will be recognized at the official luncheon session on June 28.

A. P. Olches Is Chosen Peabody Chief Engineer

The appointment of A. P. Olches as chief engineer has been made by Peabody Engineering Corporation. As chief engineer he will direct the engineering and research activities of the company.

Olches

A graduate of Stevens Institute of Technology, Olches holds several patents in his specialized fields of engineering and research. He became a member of the Peabody engineering staff in 1928 as a sales engineer. From this position he advanced to sales manager and later he became manager of research and development.

Synthetic Fuels Head Pictures 1975 Outlook

Only 20-25 percent of the total United States demand for petroleum products can be met with domestic oil by 1975, W. C. Schroeder, chief of the synthetic fuels division of the Bureau of Mines, estimated in a recent talk. In 25 years he predicts annual domestic production will drop to about 1.2 billion barrels, but domestic demand will be between 4.7 and 6.0 billion barrels annually.

The 1975 production figure was based on the estimated 120 billion barrels of domestic oil available to the United States, including oil which has been produced and anticipated production from new discoveries and extensions of old pools, he said.

Tide Water Elects Kinter

Among five vice presidents recently appointed by Tide Water Associated Oil Company was G. R. Kinter. Joining the company as a refinery chemist in 1921, he became manager of the manufacturing department of the Mid-Continent division in 1937. He has been vice president of Tidal Pipe Line Company, subsidiary of Tide Water, since 1934.

C. Neal Barney Dies

C. Neal Barney, vice president, secretary and general counsel of Worthington Pump and Machinery Corporation, died April 24 in Scarsdale, N. Y. He joined the company as chief counsel and secretary in 1918 and was appointed secretary-treasurer in 1932. In 1948 he became vice president and secretary. A graduate of Tufts College and Boston University, Barney was a member of the Massachusetts, New York state and American Bar Associations.

G. W. Jarvis Dies

G. W. Jarvis, 42, chief engineer in the refining department of McColl-Frontenac Oil Company, Ltd., died March 17 in Montreal, Quebec, Canada. A graduate of Queen's University, he received his degree in mechanical engineering. He taught at the university for two years before joining McColl-Frontenac in 1934. He is a member of the Engineering Institute of Canada and the Corporation of Professional Engineers of Quebec.

Fixes Shale Oil Extraction Cost At $2.30 Per Barrel

Including mining and retorting costs, the Bureau of Mines has estimated that oil can be extracted from shale at a cost of about $2.30 per barrel, Boyd Guthrie, chief of the demonstration plant at Rifle, Colo., has stated. A test run last September showed direct costs of 49.7 cents per ton in the top 27 feet of a 70-foot section, but improvements in equipment and mining technique should lower costs, he pointed out. The retorting costs are not based on any particular type of retort but are derived from a knowledge of all retorting processes and experience with the N-T-U and gasflow retorts, he said.

Carbide's New Chemical Research Center Includes "Last Word" in Setup, Equipment

One of the most versatile and up-to-date chemical research centers in the world is just being put into operation by Carbide and Carbon Chemicals Corporation, according to Dr. G. O. Curme, Jr., vice president of Carbide and Carbon Chemicals Corporation and vice president Chemicals Research, Union Carbide and Carbon Corporation. This new organic chemical research center, located near the company's South Charleston, plant, when completed, will be the largest single laboratory project the corporation has undertaken.

Built for the purpose of continuing and expanding the basic research work that, in the past, has given birth to such chemical products as "Prestone" anti-freeze, "Vinylite" plastics, and "Pyrofax" bottled gas, the new establishment is equipped according to the latest thinking on chemical research facilities. As typical examples, ingenious supports in each laboratory permit complete versatility in the location of laboratory furniture and equipment, and each laboratory can draw on any one of 14 separate utilities from permanent outlets—including such services as cold brine, oxygen, hydrogen, nitrogen, and steam at either 15 or 200 psi.

Features of the completed portion of the new research center were shown to members of the research committee of Union Carbide and Carbon Corporation at a meeting last month.

Chemical and Resin Research

At present only the main research building, devoted to basic research, is being occupied with four large development buildings to be occupied in the future. The completed project will eventually house fundamental organic chemical and resin research, as well as process development work.

The programs in the new research center will concentrate on the design of new chemical molecules. Research will be directed to the development of new plasticizers, new synthetic resins, and new organic chemicals for agricultural and other uses.

In the past, the fundamental research on organic chemicals carried out by Carbide and Carbon Chemicals Corporation has resulted in the commercial production of many new materials upon which whole industries have been founded. For example, the series of vinyl resins gave impetus to a new plastics industry, by opening huge new markets for flexible plastics to be used in fabrics, coatings, molded objects, electrical insulation and other fields. More recently, polymeric materials such as the polyethylene glycols, synthetic lubricants, and resinous plasticizers; a new line of fungicides, fly repellents and other agricultural chemicals; and several thousand other organic chemicals have been sythesized. These are becoming of substantial importance commercially.

A typical achievement was the rapid development of the process for synthesizing butadiene from alcohol, a factor in the success of the synthetic rubber program during the recent war. Coincidentially, a new styrene process was brought into large scale production in record time.

In 1945 the preliminary designs for the new research facilities were prepared. Subsequent studies indicated that many improvements could be made over the original plans. The new main building is now considered to be of the finest possible design, in terms of both its over-all layout and the equipment detail, for the specialized type of work to be performed.

The laboratory building proper is designed as a three-story T-shaped structure of steel and brick, 325 ft. long by 96 ft. deep. It contains sixty-nine individual laboratories and 48 offices, a large scale laboratory, a large library, an auditorium seating 125, and necessary storage and service rooms. Now in operation also are a 40,000-pound-per-hour steam plant, a maintenance and equipment fabricating shop, and a cooling tower, all connected by subways carrying utility lines.

These new facilities will shortly house the entire research staff formerly quartered in older quarters within the company's main plant on Blaine Island, thus releasing room there for further expansion of the works laboratory and the plant process development department.

Novel Mechanical Features

Mechanical features of the new laboratory building include a number of novel arrangements and installations. Complete air conditioning, vibration absorption, a multitude of safety appliances, fluorescent lighting providing an average of 40 foot-candles at all working levels, and the most modern laboratory services and furnishings are all incorporated.

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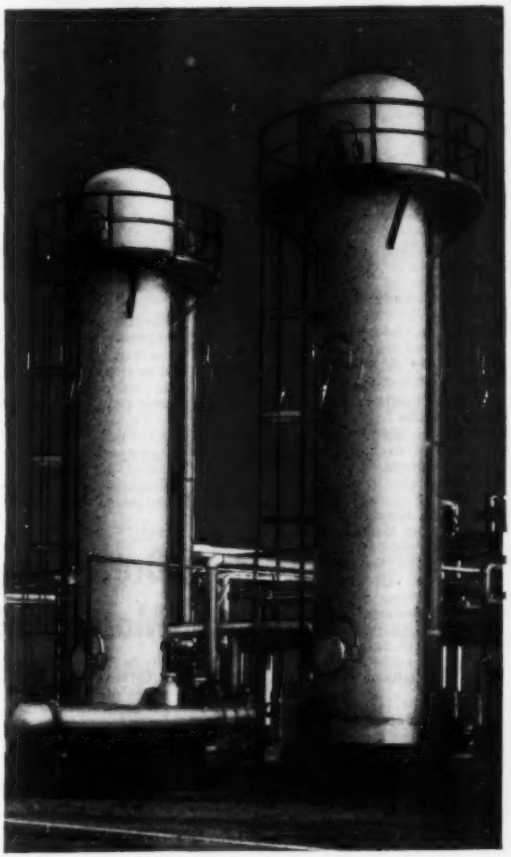

Dehydrating towers at one of the newer natural gasoline plants in southwest Texas.

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THE MONTH . . .

The individual laboratory, the production center for research, was selected as the basic starting point for development of the functional plan. Flexibility in this unit was the keynote, to permit ease of rearrangement and extensions. Individual laboratories were therefore designed as repetitive units in 13-foot wide sections or modules. The depth of laboratory rooms was set at 24 feet to accommodate multiples of standard 3-foot sections of laboratory furniture.

The standard 13 x 24-foot room accommodates two or three workers and may be equipped with any combination of laboratory furniture. All laboratories range along one wall of the building, which simplifies, with maximum economy, all service piping and exhaust duct installations.

In addition to the usual services, such as hot and cold water, distilled water, cold brine, fuel gas, compressed air and vacuum lines, all the laboratories are supplied with nitrogen, steam at 15 psi., and outlets for 110-volt a.c. with a built-in variable voltage control for controlled heating. Provision has also been made, wherever needed, for installing 200-pound steam, oxygen, and hydrogen, as well as 220-volt a.c. Outlets for connections to laboratory apparatus are located at the rear of each bench to permit removal of the furniture without disturbing the service lines.

All service supply lines extend through vertical shafts from main headers in the basement at each bay, and connections are made at each floor to permit horizontal run-outs. From the horizontal lines, branches to the service strips at the rear and above the laboratory benches, to hoods, to distillation areas, and to sinks run either along the partition walls or in recesses in the floor. Covered floor recesses and other enclosures are all easily accessible. In addition, access doors to the vertical shafts are located in the corridors to permit shutting off utilities in individual laboratories in case of emergency.

Specialized Hood Design

Most of the laboratories are equipped with fume hoods. Since the operation of a fume hood requires much more air than can be economically supplied from the conditioning system, each hood has an independent supply of clean, tempered air. When a hood is placed in operation, the air supply duct is opened and the exhaust fan speed is doubled. Both these operations are accomplished by throwing a single lever.

Vertical duct systems for air conditioning and fume hood exhausts are all located in the center of the building adjacent to columns. In this fashion, ductwork is held to a minimum and is hidden from view.

Employe safety has received careful consideration. The air conditioning system is designed to prevent contamination of the building with toxic or flammable vapors. In addition, the basement and pipe shafts are continuously purged by exhaust fans located in the penthouse. The doors from the laboratories to the 100-yard long corridors are double hung and swing outward, one leaf being provided with panic hardware. At the opposite end of each laboratory is an escape door to the adjoining room. The stairwells and exit doors are so located that it is possible to leave by at least two routes from any point in the building.

To insure personnel safety, the laboratory center has the following: a fully equipped medical dispensary with a nurse in attendance, an eye-washing fountain in each laboratory, and safety showers, blankets, stretchers and gas masks in the corridors. Fire protection equipment includes a "rate of rise" detection system that actuates a central station alarm in the telephone switchboard room as well as alarm bells in other parts of the building; two small carbon dioxide extinguishers in each laboratory, and numerous larger ones as well as fire hoses with fog nozzles in the corridors.

Investigation of chemical reactions at extreme pressures is an important part of the Carbide and Carbon Chemicals Corporation research activities. For this purpose a separate high-pressure laboratory building is located at the back of the plot. High-pressure equipment is housed in individual cells facing a high earth bank. An 18-inch reinforced concrete barrier separates the control corridor from the cells and protects operating personnel. In front of the control corridor are laboratory and work rooms. The partition walls between cells are made of two ¾-inch steel plates separated by 3 inches of sand fill. Access to the cells is provided by aisleways so arranged that equipment that is out of service can be reached for servicing without going in front of any equipment that may be operating.

Oronite Chemical Elects Two For Executive Offices

Hughes

Anthony

Oronite Chemical Company has elected T. G. Hughes executive vice president and B. W. Anthony a director and secretary-treasurer.

Hughes, who went to work for Standard Oil Company of California in 1926, has been with Oronite since its formation in 1943. Anthony is transferred from California Spray Chemical Corporation, another subsidiary, which he joined in 1943 as chief accountant. He subsequently was made a vice president of Cal-Spray.

Paul Wolfe Transfers

Paul Wolfe, formerly assistant chief process engineer at the Beaumont, Texas refinery of Magnolia Petroleum Company, has transferred to the refinery engineering department of Socony-Vacuum Oil Company. R. T. Malin succeeds Wolfe at Beaumont.

Pennzoil Elects Suhr

New member of the board of directors of The Pennzoil Company is Henry B. Suhr.

Broeze Says Octane Number Increases in Motor Fuel Appear Limited for a Time

Octane increases in motor fuel seem to be limited for the present and the use of separate antidetonants must be investigated before proceeding further, Professor J. J. Broeze of the Delft laboratory, Royal Dutch-Shell Group, says in his paper, "Future Outlook of Fuel Utilization," prepared for presentation at the United Nations Scientific Conference on the Conservation and Utilization of Resources. The cracking process has brought more material within the volatility range than the gasoline engine can consume, at the same time helping along with the other chemical conversion processes to adapt the hydrocarbons to the combustion process desired, he pointed out. Feeling that it has reached its limits of possibility and fearing a reduction in yield per barrel of crude that would offset gains in performance or economy, the industry will not contribute to further adaptation and other possibilities must be investigated, Broeze explained.

One of the possibilities to be investigated, Broeze said, is the introduction of a special antidetonant fluid for combustion, which is based on petroleum or water-methanol, with tetraethyl lead added. The principle may become very important in this field, he added.

Discussing the internal combustion turbine, he pointed out that, although the turbine is tops as regards performance, "the bigness of the object, when it is built for economy, makes it cumbersome for experimentation." It can show "in compound form, that is, in combination with high supercharge and full utilization of exhaust energy, the lowest possible consumption figures."

For trains, he said, the days of the steam locomotive are numbered—the oil engine is the solution at present aimed at by every railroad in the world. However, the internal combustion turbine may become very attractive because of its compactness in big powers.

The internal combustion turbine is seen by Professor Broeze as the possible answer to the problem of providing a safe fuel for civil aviation. He pointed out that while civil aviation made use of material developments, it has never been able to insist on what it would like to demand—a safe fuel. The internal combustion turbine is already at the top as regards performance and will be acceptable soon for economy. It is very

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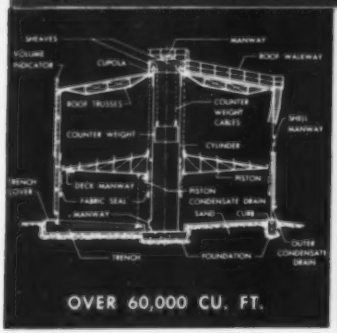

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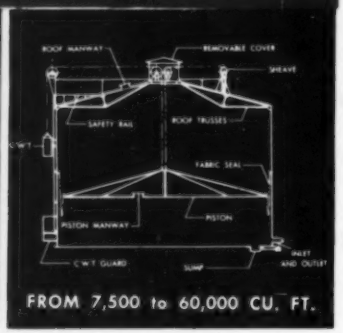

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2. A vapor balancer that has a 100% Dry Seal.

a. Eliminates corrosion problems attendant with wet seals.
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3. One vapor balancing mechanism for all tanks.

a. Provides flexibility of operation.
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c. Allows vapor balancer to be removed without disturbing storage tank operation.
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THE MONTH . . .

likely that the persistent cry for increased safety in civil flying could be answered satisfactorily by the use of inexpensive fuels of low volatility. Safety and smooth noiseless motion would add to the attractions and the usefulness of flying, he said.

R. H. Hazlett Is New Oil, Gas Manager for Blaw-Knox

R. H. Hazlett has been appointed manager of the oil and gas department of Blaw-Knox Company and Arne Olson is to become chief process engineer of the chemical plants division.

Hazlett

Also serving as manager of gas equipment at one of the company's plants, Hazlett has concentrated on dust collection and gas conditioning developments. He is a graduate of the University of Pittsburgh, and joined Blaw-Knox in 1933. He was named manager of the gas equipment department in 1946.

Olson was formerly chief engineer of process equipment. He is a specialist on synthetic resins.

Atlantic Research Holds Anniversary Celebration

To celebrate the 25th anniversary of its organization, the research and development department of The Atlantic Refining Company held open house on May 21 at the research center in the Point Breeze, Pa., refinery. The recently completed research administration building and the new pilot unit building were opened to the public for the first time.

Exhibits were arranged to show the various steps in modern petroleum research, from the first stages of experimentation to the development of the final products. There were also demonstrations of the research going on to develop future uses for petroleum products.

Canadian Dow Selects Three New Directors

New members of the board of directors of Dow Chemical of Canada, Ltd. are Calvin A. Campbell, Conald Williams and Ralph M. Hunter. Campbell is secretary and general counsel of The Dow Chemical Company. Williams is director of sales and Hunter is manager of the electrochemicals division.

Campbell was elected secretary and Williams was elected vice president of the Canadian subsidiary also.

Aramco Names Directors

B. W. Letcher and C. L. Harding have been elected to the board of directors of Arabian American Oil Company replacing A. N. Kemp, a director of Standard Oil Company of California, and B. B. Jennings, president of Socony-

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Vacuum Oil Company, Inc. Letcher also is a vice president and director of Standard of California, while Harding is a vice president and director of Socony-Vacuum.

Hall and Russell To Head Bahrein Research Activity

Alan E. Hall has been appointed superintendent and Harold G. Russell assistant superintendent of the research and development department of The Bahrein Petroleum Company Limited at its Bahrein, Persian Gulf refinery. Hall replaces George S. Windle who has been transferred to the New York office of California Texas Oil Company, Limited.

Named Vice President

Harold Bottomley, former chief process engineer for The Refinery Engineering Company, has been appointed a vice president of the company. He will contact clients in widely scattered sections of the country. Previous employers were Republic Oil Refining Company, Cities-Service Oil Company, Cosden Petroleum Corporation, Shell Oil Company and Kanotex Refining Company.

AUTHORS

■ CONTINUED FROM PAGE 163

the University of Pittsburgh and has a degreee in petroleum engineering. His career in the oil industry began with Standard Oil Company of New York.

During the war he received important assignments in the manufacturing department of Socony-Vacuum in New York City, and also served as a member of the PAW aviation gasoline advisory committee.

With Houdry he has served as manager of the project analysis department and as technical consultant for Houdry licensees on problems pretaining to reconversion of plants from wartime operation to peacetime production; the modernization of refinery equipment; and, the installation of new catalytic cracking equipment. He has authored a number of papers on catalytic cracking.

George F. Hornaday is a member of the engineering department of Houdry in Philadelphia, having transferred from the Linwood Laboratories in 1948. He came to Houdry on a personnel loan in 1940, which became permanent in 1946. Previously, Hornaday had been in the research and development division of Socony-Vacuum since 1936.

Hornaday graduated from Purdue University in 1935 with a B. S. in chemical engineering.

Bowling holds first place in his list of interests, followed by golf and fishing. Hornaday is a commuter—living in Woodbury with Mrs. Hornaday and daughter Margaret Jane and traveling to Philadelphia daily.

Before transferring to the engineering department, Hornaday was assistant head of the development division and assistant manager of the research and development division in the laboratories in Linwood for Houdry.

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... designed specially for the storage of corrosive oil products. The entire under surface being in complete contact with the tank contents, no vapors are trapped or can collect beneath the roof.

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Write for bulletin FR-3 which gives further details on Wiggins Lodek Floating Roofs.

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BOOKS of Interest

Important Distillation Treatise Is Translated

Distillation and Rectification, by Dr. Emil Kirschbaum, Professor, Karlsruhe Institute of Technology. Translation by M. Wulfinghoff, Engineer, with the Sanderson and Porter organization. Published in 1948 by the Chemical Publishing Company, Inc., Brooklyn, New York, by authority of the Alien Property Custodian under License No. A-1019. 426 pages, $10.00.

This first English language edition of an important German book has much of interest for the oil industry engineer, specializing in distillation principles, calculations, and equipment. As noted by the author in his preface, the individual branches of distillation equipment design "have not yet been treated with the thoroughness they deserve." One reason for this has been that practical experience and necessity in manufacturing many products has placed industrial practice well ahead of theory. The author states that this condition has been samewhat alleviated in Germany by the adoption of chemical engineering as a subject for advanced technical study and research. Much work has been devoted to distillation and rectification. The purpose of his book, then, is "to close one of the gaps in the literature and to present results of research together with engineering data."

"The subject matter is not divided by specific industries such as alcohol or petroleum distillation, gas liquefaction, solvent recovery, Buna processing, and so on," it is pointed out. "Instead, principles and generally suitable designs have been stressed and numerical and descriptive examples referred to specialized industries. Certain processes have been demonstrated for the case of binary mixtures only, although they may involve liquid mixtures of more than two individual substances." The author further notes that "in technical thermodynamics, it has become the custom to use (in the treatment of binary mixtures by graphical methods) the enthalpy-concentration diagram method exclusively. In distilling and rectifying, methods which rest on the assumption of constancy of molal heat of evaporation have been adopted. Each of these methods has its advantages and drawbacks. Therefore both have been considered although the second method has been more extensively used because of its importance in dealing with mixtures of several components."

Graphical methods of calculation are much used in this book, and a number of photographs illustrating bubble tray behavior are included. Typical examples of industrial applications are in the main devoted to binary and ternary mixtures encountered in the alcohol and hydrocarbon chemicals industries. The volume would seem to be of high importance to the serious student of distillation, but of considerably less interest to the practical engineer or operator of process equipment in refineries and natural gasoline plants.

Screw Thread Standard Modifications Listed

Modifications in the Unified and American Screw Thread Standard of the American Society of Mechanical Engineers include the addition of Classes 2A and 2B.

Class 2A is an external thread classification which provides an allowance or clearance between its maximum metal condition and the minimum metal condition of any class of internal thread into which it assembles. This clearance minimizes galling and seizing in high-cycle wrenching and high temperature applications. It also accommodates plating when required. This class is the standard practice for the production of screws, bolts and other threaded fasteners.

Class 2B is a realistic approach to the tolerances required in the production of standard nuts.

German Research Papers Abstracted In Catalogue

Descriptive abstracts of more than 200 translations of German wartime scientific and industrial research reports appear in Catalogue No. 1, issued by Consultants Bureau, 153 West 33 Street, New York City. The catalogue is available without charge if requested on firm or organization stationery.

The bulk of the reports abstracted in the catalogue were recommended for translation by American Petroleum Institute Technical Oil Mission Film Study Groups. The reports cover a wide range of material, pertinent to such fields as fuels and lubricants, industrial chemicals, industrial gases, chemical engineering, engine testing, plastics, soaps, rubber, paints, textile aids, chemical analysis, etc.

Interscience Publishers Release Its 1949 Catalog

Interscience Publishers, Inc., 215 Fourth Avenue, New York 3, N. Y., have released their 1949 catalog on books and periodicals. The catalog contains a complete listing of all the firm's publications either in print or in active preparation.

Technical books are listed in the catalog under headings of chemistry, physics, mathematics, metallurgy, engineering, medicine, and general science. Also included is a listing of periodical publications—abstract services and journals—a list of series, author index, and subject index.

Detailed information about most of the books listed in the catalog is available in descriptive folders, which will be sent on request by Interscience.

Many Questions About Oil Answered by API Booklet

Pubished by the Department of Information of the American Petroleum Institute, "Petroleum, The Story of an American Industry," provides answers to many questions regarding the origin, source and uses of petroleum and its products, as well as giving information about the operations of the industry itself.

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"A Professional Guide for Junior Engineers," written by the late Dr. William E. Wickenden and edited by G. Ross Henninger, presents the philosophy and engineering ethics a young engineer needs for success.

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Hydrocol Process Cited

The motor fuel supply of America could be increased 25 percent by the Hydrocol process for converting natural gas into gasoline, Ernest O. Thompson, Texas Railroad Commissioner, said at the recent testing of air-flow centrifugal compressors at Hydrocarbon Research, Inc., for the new Carthage Hydrocol plant at Brownsville, Texas.

Teeters Joins Kellogg

Wilber Otis Teeters has joined The M. W. Kellogg Company at the Jersey City laboratory of its Petroleum and Chemical Research Department. He is associated with product development activities in the petroleum and chemical fields.

Douglas Oil Appoints

Douglas Oil Company of California has appointed John J. Stanko manager of its processing asphalt division. He was formerly director of research with Flintkote Company, working in the company's research and development phases of the asphalt products field.

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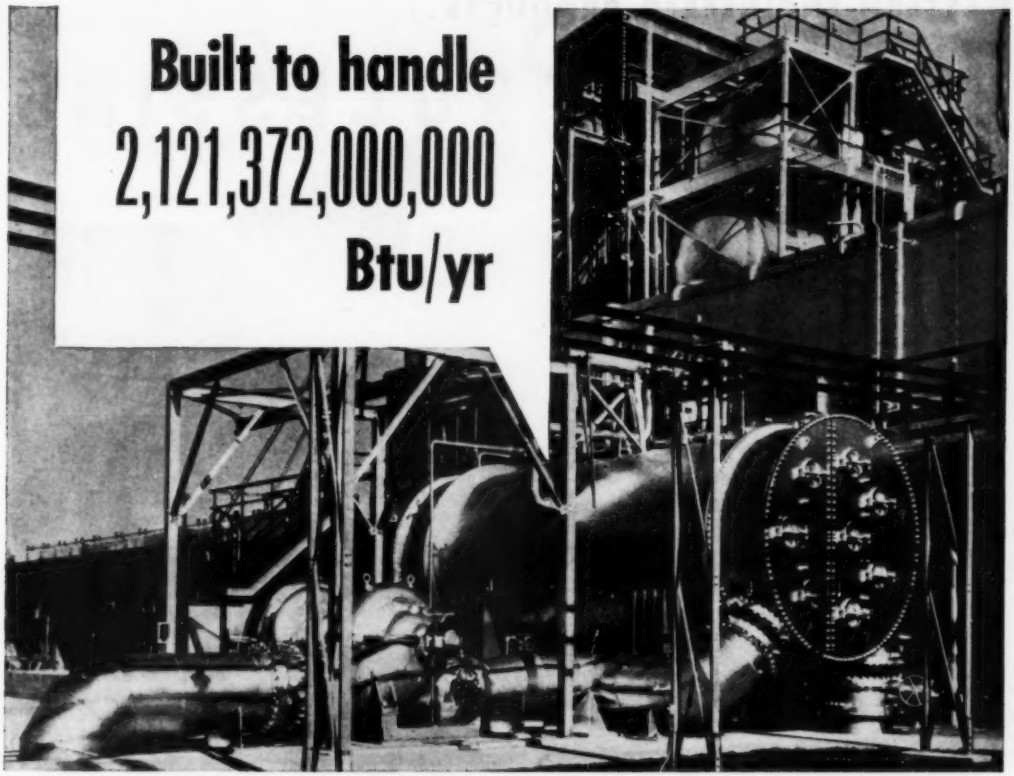

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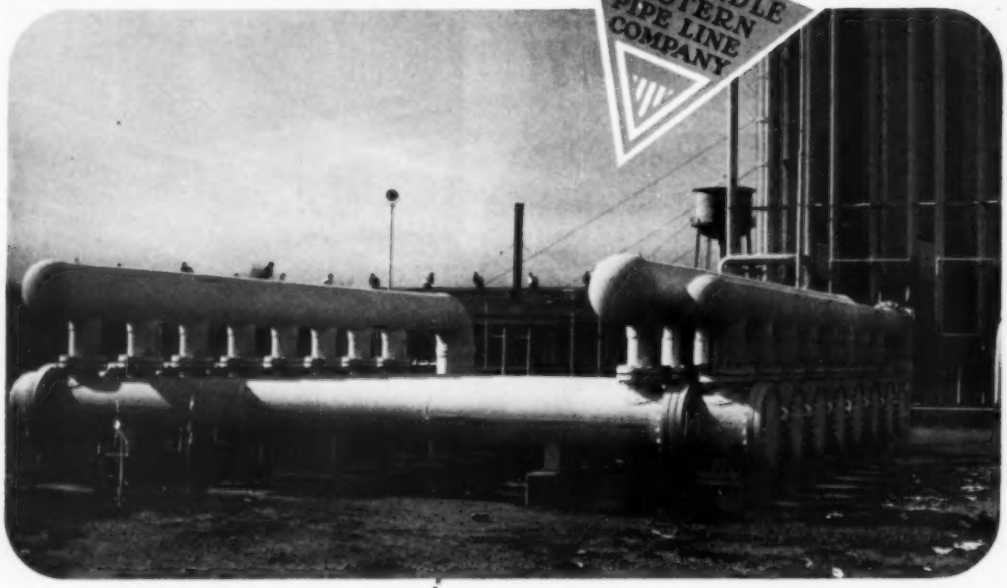

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SCIENCE and TECHNOLOGY Abstracts

Prepared by
DR. E. H. LESLIE and DR. H. B. COATS
The Leslie Laboratories
Traver Road, Ann Arbor, Mich.

These abstracts are selected from the current literature of science and technology, not including trade journals easily available. Photostatic copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, also will be prepared and furnished by arrangement with the Laboratories.

Chemical Composition and Reactions

Carbon Hydrogen Groups in Hydrocarbons. R. R. HIBBARD AND A. P. CLEAVES, *Analytical Chem.*, **21** (1949), pp. 486-92.

Average number of primary CH_3, secondary CH_2, and CH groups in hydrocarbons can be determined by absorption spectroscopy in the 1.10 to 1.25μ range near the infrared region. A slightly modified, small glass prism spectrometer is used. Because of the fact that the absorption of these functional groups is substantialy constant for all hydrocarbons in a given class, calibration with a few members of this class permits the analysis of streams containing any number of components of the same class. Estimates of the amount of chain branching in paraffins and of the degree of substitution in naphthene and aromatic rings can be made. Judged by the results from blends of pure components, average deviations of less than 0.15 CH_3 and CH_2 groups will be found in the analysis of paraffins and aromatics, and less than 0.4 of these same groups in naphthene or paraffin-naphthene blends. Although the average deviation in the determination of the aromatic CH group was less than 0.1, it is believed that this accuracy cannot be expected in the analysis of the petroleum fractions. The data are presented in considerable detail in tabular and graphical form, and a bibliography of 12 references is included.

On the Chemical Composition of Oxidized Mineral Oils. D. J. W. KREULEN AND F. G. KREULEN VAN SELMS, *Jour. Inst. of Petroleum*, **35** (1949), pp. 88-96.

Chemical compositions of an oxidized white oil and of an oxidized transformer oil were studied. Soluble oxidation products and also those that precipitate as "resins" from oxidized transformer oil are largely carbonyl-containing hydroxy acids and anhydrides of these acids. Molecular weights of the oxidation products, "resins" included, are about the same as fresh oil. Formation of larger molecules during oxidation was not observed. Fractionation of oxidized oils by the aid of solvents results in the accumulation of oxidation products that are constitutionally similar. Ester values of oxidized oils point not to esters but to anhydrides. The increase in viscosity of oxidized oils is not caused by molecular weight increase but by the appearance of polar groups, of which carbonyl groups are most effective. Some results on the deterioration of lubricating oil in an aircraft engine are reported.

Pyrolysis of 2-Pentene and Trimethylethylene. H. J. HEPP AND F. E. FREY, *Ind. Eng. Chem.*, **41** (1949), pp. 827-30.

Cracking reactions of the amylenes are of interest from the standpoint of reaction mechanism studies and of diolefin production. Yields of diolefin are favored by high temperature, and most previous work has been conducted at too low temperature to obtain maximum yield. Trimethylethylene and 2-pentene were cracked in quartz by a flow method at temperatures in the range 778° to 850° C. in the presence of varying amounts of steam. Butadiene was the major product from 2-pentene, the yield ranging from 33 to 55 moles per 100 moles of 2-pentene reacted, depending upon conversion, temperature, and dilution. Pentadiene was also formed in amounts approximating 10 moles per 100 moles reacted. Ethane and butene appeared to be primary reaction products along with butadiene, ethylene, and propylene. Isoprene was the major product obtained from trimethylethylene, the best yield being 38.3 moles per 100 moles reacted. Butadiene yields of approximation 10 moles per 100 moles reacted were also obtained. Butylenes that were formed in very large amounts were of the order of 40 moles. The apparatus used and the operation of the equipment are described in some detail, and the results are presented in tabular form. A bibliography shows 11 references.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

4,6-Bis(chloromethyl)-1,3-xylene
Tri-(p-isocyanatophenyl)methane
Phenanthridine
1-Decalone
1-Decalol
2,5-Diethylbenzoic acid
2,5-Diisopropylbenzoic acid
1,3-Dimercaptobenzene
n-Octacosanol
3,4,5-Trimethylphenol
Dilauryl disulfide
1,6-Dihydroxynaphthalene
2,3-Dihydroxynaphthalene
2,5-Thiophane dicarboxylic acid
3-Methyladipic acid
Propadiene
1,3,5-Hexatriene
1,2-Heptadiene
1,2-Hexadiene
Cyclopropanone

Alkylnaphthalenes. Part III. The n-Butyl- Amyl- and Hexylnaphthalenes. A. S. BAILEY, G. B. PICKERING AND J. C. SMITH, *Jour. Inst. of Petroleum*, **35**, (1949), pp. 103-117.

The six hydrocarbons described form a set of homologues in which the strongly aromatic character of naphthalene is in many respects diminished as the aliphatic proportion of the molecule increases. The preparation of the compounds is described, and their properties are given in some detail. A bibliography shows 17 references.

Synthesis of Chlorofluoropropanes. DONALD D. COFFMAN, RICHARD CRAMER AND G. W. RIGBY, *Jour. Am. Chem. Soc.*, **71** (1949), pp. 979-80.

The authors successfully effected the aluminum chloride catalyzed addition of chloromethane and chlorofluormethane to tetrafluoroethylene. It was found that reactions of chloroform or carbon tetrachloride with tetrafluoroethylene, of dichlorofluoromethane or trichlorofluoromethane with tetrafluoroethylene or chlorotrifluoroethylene, and of dichlorofluoromethane with tetrachloroethylene, all proceeded normally without appreciable replacement of fluorine by chlorine. Halogen replacement occurred in reactions involving chlorodifluoromethane. The results of the work are tabulated to give the structure of the products, the yields in which they were obtained, and the physical properties of the various compounds.

Thermal Decomposition of Lead Mercaptides. GEO. E. MAPSTONE, *Jour. Inst. of Petroleum*, **35** (1949), pp. 132-7.

During an investigation of the properties of solutions of lead mercaptides in gasoline it was observed that, even in the absence of elemental sulfur, the mercaptides decomposed slowly on standing and more rapidly on exposure to sunlight. If the solution is boiled, a black precipitate of lead sulphide is formed, and so it is apparent that the mercaptides form lead sulfide and dialkylsulfide. This reaction was studied and it was found that the thermal decomposition of lead mercaptide in gasoline solutions is a first order reaction with respect to mercaptan content. The effect of temperature on the reaction-rate constant is given by log $k = 10.63 + 4254/T$. The

Science - Technology

rate of decomposition appears to be independent of the particular mercaptans involved. The mechanism of the decomposition reaction is discussed, thermal decomposition of the lead mercaptides may be of commercial application as a sweetening process because half of the sulfur is removed. The decomposition of lead mercaptide is 99 percent complete in 10 minutes at 102° C. and in 24 hours at 42° C. Mixing with doctor solution and then separating and standing for the required time at the chosen temperature, followed by water washing and sand filtration will result in a sweet gasoline without the expense and inconvenience of adding sulfur, and with a sulfur reduction of half the initial mercaptan-sulfur content.

Evaporation Processes in a Burning Kerosine Spray. H. G. WOLFHARD AND W. G. PARKER, *Jour. Inst. of Petroleum*, **35** (1949), pp. 118-125.

The authors discuss the evaporation of kerosine droplets in a fine spray burning in still air at room temperature. A theoretical discussion of the heat available for evaporation shows that under the conditions examined no appreciable evaporation of the droplets occurs before the preheating zone of the flame. This zone is narrow, but there is time for the smallest droplets to vaporize and diffuse into the gases in this zone. Thus an inflammable mixture is formed that maintains the flame front. Some evidence in support of this argument was obtained from photographs of kerosine droplets before entering the preheat zone of a non-aerated Bunsen-type acetylene flame. Several excellent flame photographs are presented.

Manufacture: Process and Plant

Distillation Column Design for Processing Polymerizable Compounds. K. F. COULTER, *Chem. Eng. Progress*, **45** (1949), pp. 227-34.

The author is concerned with distillation column design with regard to special requirements in design when polymerizable compounds are being handled. A primary consideration is the design of the column and the rate of polymerization of the monomer at various temperatures. Methods of determining the rate of polymerization are considered. Formation of gels is also an important consideration. The use of inhibitors is discussed. Vertical tube reboilers give the lowest inventory and the highest heat transfer coefficient. A low temperature difference between the material boiled and the heating medium should be used. Vacuum feed is frequently required. Any column used should be readily cleanable. Design of condensers is considered and discussed. Any pump used should be as free as possible from bearings and other parts where monomers can collect and polymerize. All pumps should be put in in duplicate. A bibliography shows 16 references.

Commercial Desalting Unit Employing Fiberglas as Contacting Agent. J. G. HAYES, L. A. HAYS AND H. S. WOOD, *Chem. Eng. Progress*, **45** (1949), pp. 235-40.

The problem of removing inorganic salts from crude petroleums before refining has become increasingly important in recent years. These salts are usually present as minute crystals or in a fairly concentrated aqueous solution emulsified in the oil. A process has been developed in which relatively fine glass fibers are used as the contacting agent in the solid contact method of desalting crude petroleum. The process comprises washing the crude oil with fresh water, heating the resulting emulsion to a temperature of 200° F. or higher, passing the emulsion through beds of glass fibers to coalesce the emulsified water, and separating the desalted oil from the water. A full scale demonstration unit processing 10,000 barrels per day of a West Texas crude that carries from 100 to 200 pounds of salt per 1000 barrels was built. The original glass packing is still in service after more than one year of continuous operation. Eighty percent of the salt was consistently removed, and as high a removal as 94 percent was obtained at times. Detailed data are given in tabular and graphical form and a bibliography of six references is included.

Production of Hexachlorobutadiene. E. T. MCBEE AND R. E. HATTON, *Ind. Eng. Chem.*, **41** (1949), pp. 809-12.

The investigation covered the chlorination of polychlorobutanes at high temperature and various pressure in a tube without the employment of a catayist. In a continuation of chlorination-chlorinolysis studies, hexachlorobutadiene was produced as the main product of the chlorination of polychlorobutanes at high temperature and atmospheric pressure. Simultaneous chlorinolysis yields some carbon tetrachloride, tetrachloroethylene, hexachloroethane and hexachlorobenzene. Starting materials were prepared from butane or chlorobutanes by photochemical chlorination. The polychlorobutanes thus produced were passed, with chlorine, through the tube and the products recovered. The hot tube chlorination process was studied extensively to determine the optimum conditions for the production of hexachlorobutadiene. Yields in excess of 75 percent of this interesting chlorocarbon having conjugated double bonds can be obtained by this new procedure. The optimum temperature for the production of hexachlorobutadiene was found to be about 475° C. An exposure time of 4 to 8 seconds gave the highest yields. The best yields of hexachlorobutadiene were obtained with a ratio of 4.0 to 1 of chlorine to polychlorobutanes and by using polychlorobutanes having a specific gravity of about 1.66. The data are presented in considerable detail in tabular and graphical form.

ASME Plans New Chapter

A Sabine-Neches area chapter of the American Society of Mechanical Engineers has been approved for membership. Roy M. Ferris, Ronald Ware and Jack Humble, all associated with Magnolia Petroleum Company in the Beaumont, Texas, refinery, are the president, secretary and program chairman respectively. They will hold office temporarily pending dispatching of invitations to other industries in the area.

Gas Absorption. Mass Transfer Coefficients as Function of Liquid, Gas Rates, Tower Packing Characteristics. LEROE E. HUTCHINGS, LEROY F. STUZMAN AND HOWARD A. KOCH, JR., *Chem. Eng. Progress*, **45** (1949), pp. 253-67.

An investigation was undertaken to determine the effect of several variables upon the mass transfer coefficients in gas absorption. Three absorption towers packed with ⅜-, ½-, ¾-, and 1¼-inch Raschig rings were used. Experiments were conducted with an acetone-air-water system covering a wide range of conditions. All experiments were at atmospheric pressure and room temperature.

The gas film transfer coefficients were correlated by two equations that are given. Both of these fitted the experimental data to within six percent average deviation. Liquid film transfer coefficients varied with the liquid rate to the 0.8 power and were independent of packing size and gas rates.

Since only one system was used, it was not possible to include a diffusivity term in the correlation. However, if diffusivity is the correlating variable between different systems, as is indicated by accepted theories, then this variable, raised to the 0.5 or first power, can be introduced into the equations given in the paper. The data are presented in detail in tabular form and a bibliography of 20 references is included.

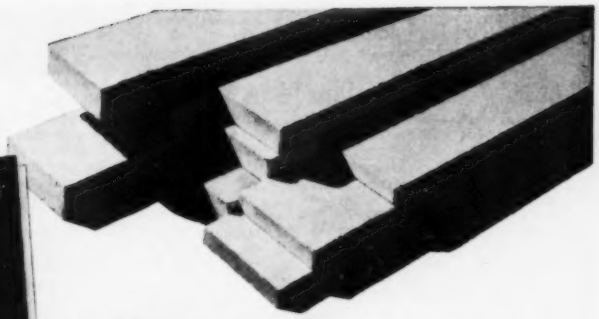
Transfer of Heat and Mass Between Air and Water in a Packed Tower. WM. H. MCADAMS, JACK B. POHLENZ AND ROBERT C. ST. JOHN, *Chem. Eng. Progress*, **45** (1949), pp. 241-52.

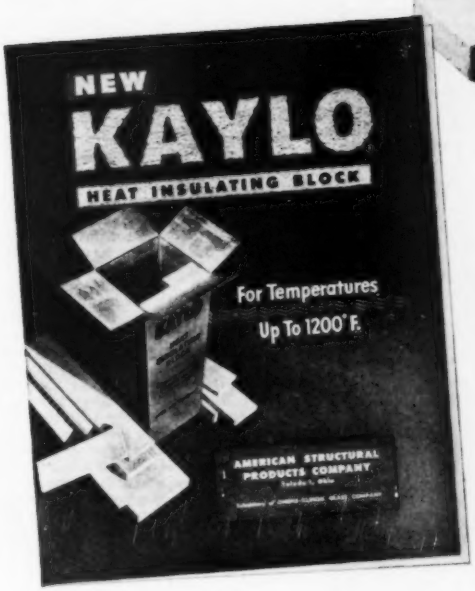
The purpose of the work was to test the basic equations for the simultaneous transfer of heat and mass between air and liquid water. True gas-film coefficients for 1-inch carbon Raschig rings were determined from adiabatic isothermal water runs and were correlated by an equation that is given. End effects were taken into account. The superficial gas velocity ranged from 350 to 1000 pounds of dry air per hour per square foot of entire cross section, the superficial water velocity ranged from 600 to 2000 pounds of water/(hr.) (sq. ft.) of gross cross section, water temperature ranged from 95 to 135° F., and gas-film temperature ranged from 115 to 205° F. Heat was applied to the outer surface of the insulation on the tower, so that operation was substantially adiabatic, and the heat balances checked within 1 percent.

The mass-transfer coefficients for the gas phase were less precise than those for heat transfer, and were lower than predicted. The apparent resistance of the liquid film to enthalpy transfer was 27 to 46 percent of the total resistance of both gas and liquid films. It was concluded that the use of an over-all coefficient of enthalpy transfer should be done with caution and that the methods presented in this paper show a more logical means of designing and evaluating the performance of cooling towers.

Dewaxing of Mineral Oil by Liquid-Liquid Extraction. T. G. HUNTER AND T. F. BROWN, *Jour. Inst. of Petroleum*, **35** (1949), pp. 73-87.

The authors discuss the possibility of replacing the present low-temperature methods of dewaxing mineral oil by liquid-liquid counter-current extraction with a solvent at an operating tempera-





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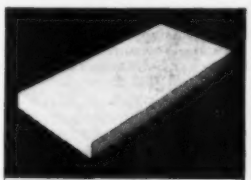

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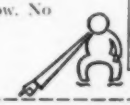

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ture above the melting point of the wax but below the critical solution temperature of the wax and solvent. Experiments were made with pure components using aniline as the solvent, and these indicated that the best separations are obtained from naphthenic and paraffinic oils, but that the number of theoretical stages required is high. A triangular diagram, employing the physical property of viscosity gravity constant to represent composition of waxy oil and with the solvent treated as if it were a third component, was employed for phase-equilibrium representation of an oil-wax-solvent system. It was shown that the tie-lines on such a diagram can be interpolated by a Bachman plot, while the wax content of solvent-free extract and raffinate phases can be obtained from a correlation between V.G.C. and wax content. Counter-current computations, made on such a diagram, obtained when using acetone at 25° C. suggest that the separation effected by this solvent is not promising.

Experiments were made employing aniline as a solvent and these suggest that, while the process is workable, yields under the conditions employed with this solvent are lower than in the conventional low-temperature dewaxing methods. The results obtained confirm the conclusions from the computations made on the oil-wax-acetone diagram that the separation achieved using a 15 percent wax-stock charge is not as economic as the present commercial methods. The indications are, from the computations made on pure components, that wax stocks of higher wax content can be treated much more efficiently.

Pore-Size Distribution in Porous Materials. Application of High Pressure Mercury Porosimeter to Cracking Catalysts. L. C. DRAKE, *Ind. Eng. Chem.*, **41** (1949), pp. 780-5.

The technique employed for the determination of macropore-size distribution, that is 85,000 to 200 A. pore diameter, has been further developed to cover the pore diameter 200 to 35 Å. The method utilizes the principle first proposed by Washburn in 1921 that for a constant surface tension and contact angle the diameter of a pore that can be entered by mercury is a direct function of the applied pressure. Pressures from 25 to 60,000 psi. were employed in the work. A detailed description of the apparatus used is given, as well as of the operational techniques. The method was applied to three types of commercial cracking catayists including activated clay and silica-alumina gels in the form of gel beads and pellets. The data indicates wide variations in the pore-size distributions of these materials. A bibliography of nine references is included.

Correlation of Operating Variables in Catalytic Polymerization. JACK H. STEFFENS, MARLIN U. ZIMMERMAN AND M. JOHN LAITURI, *Chem. Eng. Progress*, **45** (1949), pp. 269-78.

The authors present a correlation showing the effect of operating variables upon conversion in the catalytic polymerization of gaseous olefins to produce motor gasoline. A correlation was developed from the results of 25 tests run on commercial plants. It applies to the polymerization of propylene and butylene streams in tubular-type catalytic polymerization units using copper pyrophosphate catalyst. Conversion of the olefins in the total feed to the reactors increases with: 1) increase in catalyst activity; 2) increase in reactor temperature; 3) decrease in olefin space velocity; 4) decrease in total space velocity; and 5) decrease in olefin composition ratio. No relationship was found between the operating variables and the octane rating of the polymer product. However, as reactor temperature increases, increase in the ASTM 50 percent and 90 percent distillation points of the polymer occurs.

A chart is presented for predicting the weight percent conversion of the olefins in the total feed for a wide range of operating conditions. The average deviation of the predicted conversions from actual conversions is ± 2.5 weight percent. Twelve other plant tests were used to check the correlation and are shown to have an average deviation of ± 2.9 weight percent. A flow chart of a typical catalytic polymerization unit is given and the data are presented in considerable detail in tabular and graphical form. A bibliography of seven references is included.

Power Savings in Process Refrigeration. FREDERICK CARR, *Ind. Eng. Chem.*, **41** (1949), pp. 776-80.

Refrigeration systems are required to perform duties that can be divided into two main classes. The first type of duty consists in the transference of heat from a constant low temperature to a constant high temperature, as in cold storage application. The second type of duty, such as occurs in cooling a liquid of definite specific heat, requires removal of the heat at varying temperatures, and may also be required to deliver the heat at varying temperatures. This second type frequently occurs in the process industries. Analysis of the performance of different refrigeration cycles suggest the use of a varation of the vapor compression cycle, which is normally used in space refrigeration duty. This variation of the vapor compression cycle is considered and discussed.

Chlorination of Hydrocarbons. Chlorination of Ethane. E. T. MCBEE, H. B. HASS, W. E. BURT AND C. M. NEHER, *Ind. Eng. Chem.*, **41** (1949), pp. 799-803.

The paper gives a report of an investigation of the thermal and photochemical chlorinations of ethane, involving the jetwise introduction of chlorine. The introduction of chlorine through a jet into the hydrocarbons minimizes quantities of over-chlorinated products at relatively high overall ratios of chlorine to ethane, and allows the control of reaction temperature necessary for reducing the cracking of the product to a minimum. Efficient mixing of reactants, employment of low concentrations of the chlorine, accurate temperature control and facility of operation are characteristics of the process described. A bibliography of seven references is included.

Chlorination and Chlorinolysis of Propane. E. T. MCBEE AND L. W. DEVANEY, *Ind. Eng. Chem.*, **41** (1949), pp. 803-6.

Chloropropanes were prepared by the simultaneous and continuous introduction of chlorine and propane into an irradiated body of polychloropropanes having approximately the specific gravity of the desired product. The polychloropropanes were then chlorinolyzed at atmospheric pressure to produce tetrachloroethylene, carbon tetrachloride and hexachloroethane. Polychloropropanes having a specific gravity above about 1.7, produced by the continuous chlorination process, were found to be suitable charge stocks for chlorinolysis. Temperatures between 460° and 480° C. were found to be most satisfactory for production of tetrachloroethylene and carbon tetrachloride.

Production of Hexachlorocyclopentadiene. E. T. MCBEE AND C. F. BARANAUCKAS, *Ind. Eng. Chem.*, **41** (1949), pp. 806-9.

The present investigation was an extension of previously reported chlorination techniques to include the polychloropentanes and polychlorohexanes. High temperature chlorinations of polychlorocyclopentanes, polychloroisopentanes and polychloro-n-pentanes at atmospheric pressure gave hexachlorocyclopentadiene as a product in high yields, such as 75 percent. Polychloroneopentanes gave chlorinolysis products rather than hexachlorocyclopentadiene. Polychloro-n-hexanes, polychloroisohexanes and polychloro-2-methylpentanes were also converted to hexachlorocyclopentadiene by the same process. Polychloropentanes having a specific gravity of 1.63 to 1.70 were the most suitable charging stock for the production of hexachlorocyclopentadiene when using a chlorination temperature of 470° C. The most favorable mole ratio of chlorine to polychloropentanes having a specific gravity of 1.64 was 5.71 to 1., data are presented in considerable detail in tabular form and a bibliography of four references is included.

Fundamental Physical and Chemical Data

Thermodynamic Properties of Thiophene. GUY WADDINGTON, J. W. KNOWLTON, D. W. SCOTT, G. D. OLIVER, S. S. TODD, W. N. HUBBARD, J. C. SMITH AND HUGH M. HUFFMAN, *Jour. Am. Chem., Soc.* 71 (1949), pp. 797-808.

The heat capacity of thiophene was measured over the temperature range 11-340° K. and the transition points were determined. The heat of transition was found to be 152.4 cal./mole, heat of fusion 1215.5 cal./mole and the triple point 234.95° K. Vapor pressure was measured over the temperature range 0 to 120, and an equation was developed to fit the vapor-pressure data. The normal boiling point is 84.16°. Heat of vaporization was measured at three temperatures, 45.26, 63.08 and 84.16°. It was found to have the values 8032, 7808 and 7522 cal./mole, respectively, at the three temperatures. The heat capacity of thiophene vapor was measured at five different temperatures in the range 343 to 472° K. An equation is given to represent the data. Entropies of the liquid and of the ideal gas are given. The heat of combustion was determined as 667.19 kcal./mole. The heats of formation of liquid thiophene and of the gas are given.

Estimation of Liquid Diffusion Coefficients. C. R. WILKE, *Chem. Eng. Progress* **45** (1949), pp. 218-22.

A method for the estimation of liquid

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diffusion coefficients was developed on the basis of relationships suggested by the Eyring theory of absolute reaction rates and the Stokes-Einstein equation. Correlation has been made through the group $F = T/D_s$. Within the limits of available data F is essentially independent of temperature for a given solute-solvent system. For diffusion of various solutes in a given solvent, F is a function of the molal volume of the solute. Curves for F vs. solute molal volume have been developed for diffusion in water, methyl alcohol and benzene. General relations are suggested for estimating F in other solvents. The effect of concentration on the diffusion coefficient is considered briefly. Observed data for diffusion of various substances in water, methyl alcohol, benzene and 14 other solvents, including a total of 178 experiments, have been reproduced by the method with an average deviation of ten percent between calculated and observed values.

Latent Heat of Vaporization. JU CHIN CHU, MYRON DMYTRYSZYN, JOSEPH J. MODER AND RICHARD L. OVERBECK, *Ind. Eng. Chem.* **41** (1949), pp. 131-5.

From Kistyakovskii's empirical equation for the heat of vaporization at the normal boiling point, a series of equations expressing the heat of vaporization for various classes of compounds in terms of the normal boiling point and parachor was derived. For the paraffin hydrocarbons, the equation was developed further to correlate the heat of vaporization with the structural formula of the hydrocarbons. Based on this derived equation, a nomograph was developed, from which the latent heat of vaporization can be readily predicted from the number of carbon atoms, the polarity number and the path number, all of which can be determined from the structural formula of the compound. Seventy-three paraffins were included in the study. The maximum error was of the order of ±5 percent, with an average error of ±2 percent. A second nomograph, based on the same equation, but empirically corrected for the deviation from the literature values is also presented with the average deviation within experimental error. A bibliography of 19 references is given.

The Solubility of Fluorocarbons. ROBERT L. SCOTT, *Jour. Am. Chem. Soc.* **70** (1948), pp. 4090-3.

The intensive study of fluorine and fluorine compounds in the last few years has led to the synthesis of a large number of compounds in which hydrogen atoms are partially or completely replaced by fluorine atoms. The completely substituted hydrocarbons, commonly called "fluorocarbons" show lower solubility and poorer solvent power than that normally associated with non-polar organic liquids. The purpose of the work described was to determine whether the fluorocarbons can be fitted into the framework of the existing "internal pressure" theory of the solubility of non-electrolytes, or whether they are in fact anomalous. Solubility parameters were calculated for fluorocarbons, and were found to be lower than any other substances liquid at room temperature.

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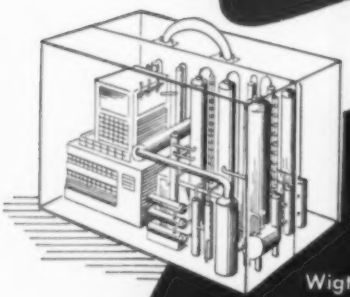

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From the Hildebrand solubility theory it was deduced that the aliphatic fluorocarbons are completely miscible with aliphatic ethers, but show only limited solubility in benzene, acetone, etc. Experimental data confirm these predictions, leading to the conclusion that the solubilities of the fluorocarbons are not at all anomalous but are only the thermodynamic consequences of their low solubility parameters.

The Solubility of Naphthalene in Supercritical Ethylene. G. A. M. Diepen and F. E. C. Scheffer, *Jour. Am. Chem. Soc.* **70** (1948), pp. 4085-9.

An apparatus was devised for the preparation and precise measurement of saturation concentrations of slightly volatile solids in fluids at temperatures above their critical points. The apparatus was used to determine the saturation concentrations of naphthalene in ethylene at 12, 25 and 35° C. and at various pressures. Concentrations found were as much as 25,000 times as great as those predicted from the vapor pressure of naphthalene and indicate a specific solubility effect. The important characteristic features of the phase-rule diagrams for the system ethylene-naphthalene in the vicinity of the critical point for ethylene are described and discussed.

Products: Properties, Utilization and Analysis

Calculating Pressure - Flow Relations for Lubricating Grease. J. W. Wilson and Gerould H. Smith, *Ind. Eng. Chem.*, **41** (1949), pp. 770-6.

The authors develop an empirical equation that permits more accurate calculation of the pressure-flow relations for non-Newtonian systems than has been previously possible. The equation takes into account thixotropic change in the flowing material. The results of numerous experiments with lubricating greases are given that satisfy the equation within the range of experimental error. The effect of pressure upon the apparent viscosity of lubricating oil grease up to approximately 1000 pounds per square inch is indicated. The data are presented in considerable detail in tabular and graphical form and a bibliography of 12 references is included.

Pycnometers for Oils. M. R. Lipkin, I. W. Mills, C. C. Martin and W. T. Harvey, *Analytical Chem.*, **21** (1949), pp. 504-7.

Two pycnometers are described that are satisfactory for the determination of density of small samples of viscous oils with an accuracy of 0.0002 grams per ml. and which are essentially free from drainage error. The cup type is particularly suitable for density measurement at a series of temperatures. The side-arm type, which fills automatically by siphoning, is advantageous for waxy and extremely viscous stocks. Sketches of the two pycnometers are given with complete dimensions. Calibration of the instrument is described. Typical data are presented in tabular form.

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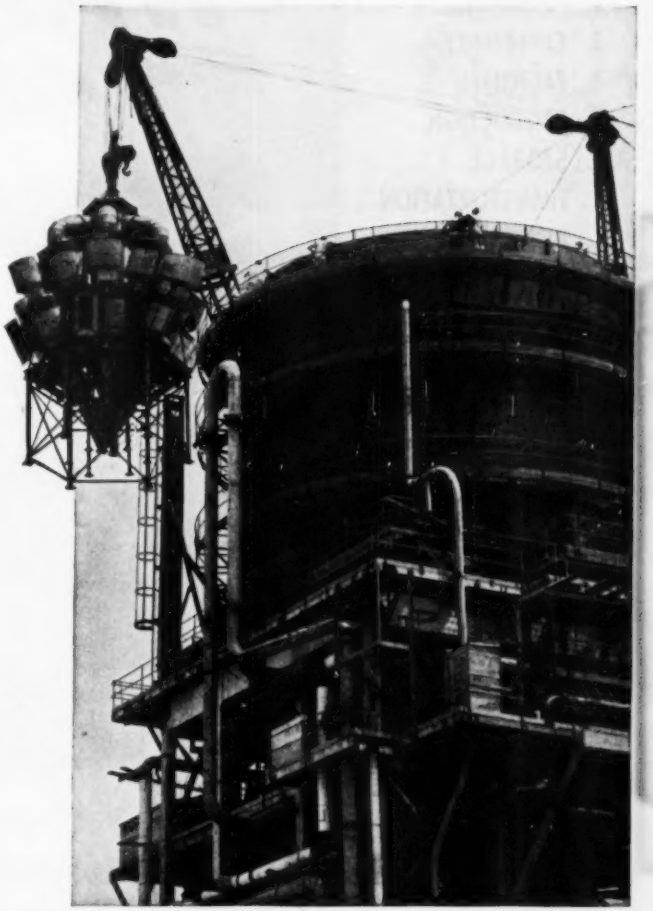

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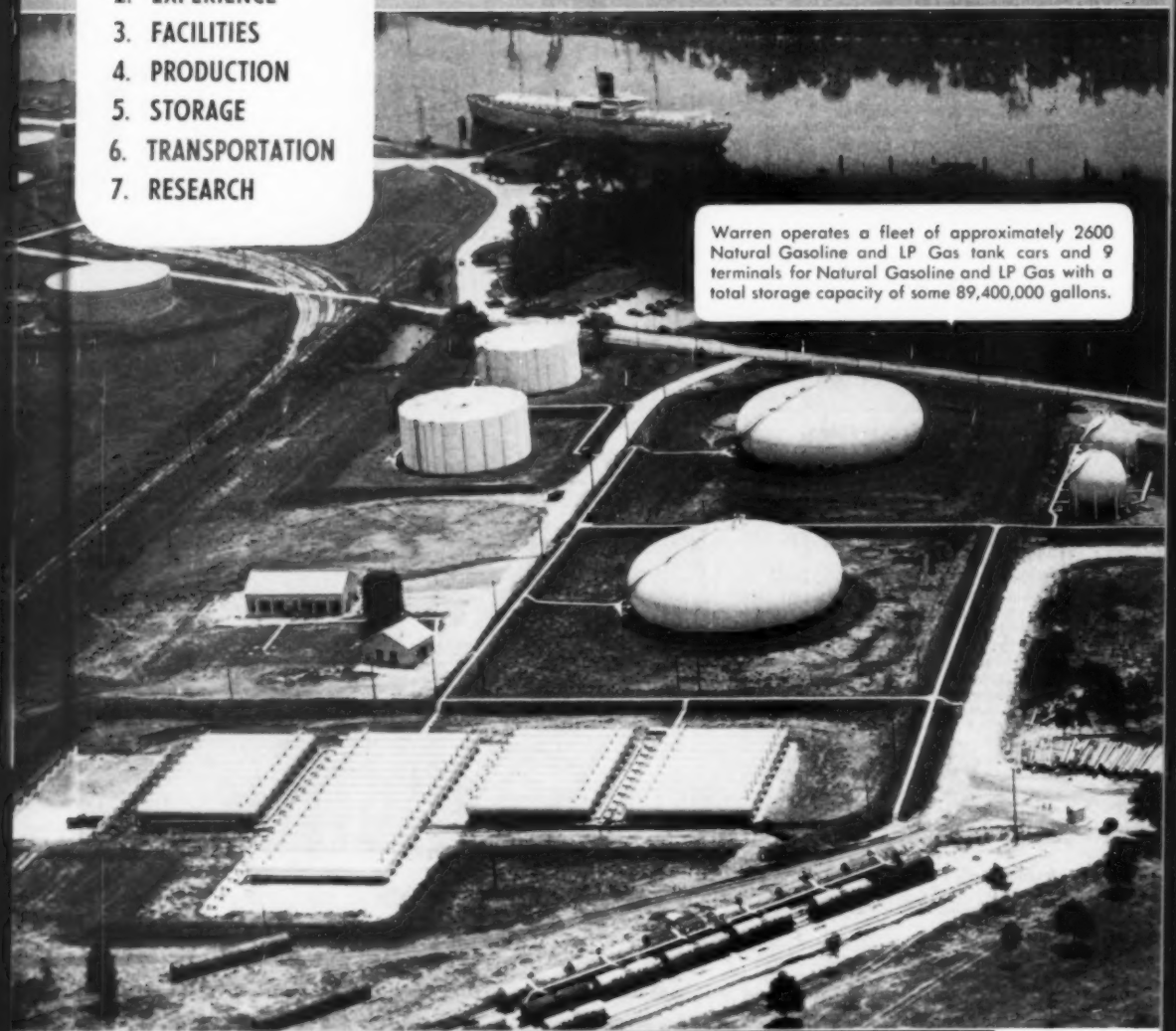

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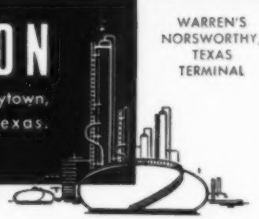

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Digest of Recent U. S. PATENTS Pertaining to PETROLEUM REFINING

Compiled by HEINZ HEINEMANN

(From the Official Gazette, March 15, 22 and 29 and April 5, 1949)

REFINING

U.S.P. 2,464,311. Recovery of Aromatic Hydrocarbons. C. R. Wagner to Phillips Petroleum Company.

The details of a process are claimed for the separation and recovery of aromatic hydrocarbons from a liquid hydrocarbon mixture also containing paraffinic and olefinic hydrocarbons. Silica gel is employed as an adsorbent and liquid low-boiling paraffins as the desorbent.

U.S.P. 2,464,769. Separating Alkyl Benzenes from Admixture with Paraffins and Naphthenes. O. M. Reiff and A. M. Moore to Socony-Vacuum Oil Company, Inc.

An aromatic petroleum stock is fractionally distilled to obtain a fraction boiling between 160.5-173° C. This fraction is chlorinated at a temperature of 15-35° C. in the presence of a catalyst to introduce 1 Cl atom into each benzene nucleus. The resulting product is fractionally distilled to obtain a fraction with a boiling point of 62-76° C. at 2.5 mms. pressure.

U.S.P. 2,464,931. Purification of Naphthenic Hydrocarbons. A. E. Hirschler to Sun Oil Company.

Naphthene hydrocarbon which contains less than 20 percent of a paraffin hydrocarbon as impurity is introduced into a body of silica gel to selectively absorb the paraffin and to obtain a filtrate of more purified naphthene.

U.S.P. 2,465,047. Azeotropic Distillation of C_4 Acetylenes from Butene-2. J. W. Tooke and E. Z. Lang, Jr. to Phillips Petroleum Company.

Butene-2 contaminated with C_4 acetylenes of higher b.p. is fractionally distilled in the presence of isobutane. An azeotrope of the C_4 acetylenes with isobutane is removed overhead.

U.S.P. 2,465,209. Motor Fuels. P. L. DeVerter to Standard Oil Development Company.

The motor fuel according to this patent consists of saturated aliphatic hydrocarbons in the gasoline boiling range, a minor amount of a lead alkyl anti-knock agent and a small amount of hydroxy benzoic acid or an ester or salt thereof. This additive inhibits the formation of a lead-containing precipitate during storage of the fuel.

U.S.P. 2,465,715. Isolation of Styrene by Azeotropic Distillation with Morpholines. K. H. Engel to Allied Chemical & Dye Corporation.

A mixture of an oil containing styrene and at least one like boiling non-styrene aromatic component with morpholine or N-methyl or N-ethyl morpholine as an azeotropic agent is fractionally distilled. A substantial portion of the non-styrene aromatic is thereby removed and an oil of substantially increased styrene content is produced.

U.S.P. 2,465,716. Isolation of Styrene by Azeotropic Distillation with Dimethylamino Ethanol. K. H. Engel to Allied Chemical & Dye Corporation.

The process according to this patent differs from that of U.S.P. 2,465,715 only in that dimethylamino ethanol is here employed as the azeotrope former.

U.S.P. 2,465,717. Isolation of Styrene by Azeotropic Distillation with Ethylene Chlorohydrin. K. H. Engel to Allied Chemical & Dye Corporation.

Ethylene chlorohydrin is here employed as the azeotrope former in a process otherwise corresponding to that of U.S.P. 2,465,715.

U.S.P. 2,465,718. Isolation of Styrene by Azeotropic Distillation with Ethylene Diamine. K. H. Engel to Allied Chemical & Dye Corporation.

In the present case ethylene diamine is employed as the azeotrope former in the process according to U.S.P. 2,465,715.

U.S.P. 2,465,950. Liquid Transference of Dicyclopentadiene. A. J. Wiss to Phillips Petroleum Company.

A crude mixture of dicyclopentadiene and heavier impurities is fractionally distilled. A mixture of di- and mono-cyclopentadiene is distilled overhead and condensed. The dicyclopentadiene of the overhead is partially depolymerized whereupon the overhead portion is returned as reflux to the fractionation to maintain the cyclopentadiene concentration in the overhead at about 2-10 percent by weight. Remaining condensed overhead is withdrawn as liquid dicyclopentadiene.

U.S.P. 2,466,593. Multiple Stage Shale Eduction Process. P. H. Jones to Union Oil Company of California.

The details of a multistage method are claimed for the recovery of shale oil from crushed oil shale. The method makes it possible to recover oil and hydrocarbon vapors at relatively low temperatures by means of the sensible heat of hot flue gas and hot lean shale gas in conjunction with superheated steam.

CATALYST PREPARATION, ACTIVATION, AND REGENERATION

U.S.P. 2,464,329. Process of Forming Low pH Hydrogel Beads. M. M. Marisic and A. C. Schmitt to Socony-Vacuum Oil Company, Inc.

The details of a process are claimed for forming a gelable hydrosol containing silica from two streams of two reactant solutions which are metered in relative proportions to form the sol at a hydrogen ion concentration greater than pH = —0.5.

U.S.P. 2,464,682. Recovery of Aluminum Halide from Aluminum Halide-Hydrocarbon Complex. H. J. Hepp to Phillips Petroleum Company.

At least a portion of a liquid aluminum halide-hydrocarbon complex, withdrawn from a hydrocarbon conversion (e.g. alkylation) zone, is destructively distilled at a temperature above 400° F. to liberate aluminum halide. Incoming hydrocarbon feed containing organic sulfur compounds and/or unsaturated hydrocarbons as impurities detrimental to the conversion process is passed in gaseous form through the complex during its destructive distillation. The impurities are thus removed from the hydrocarbon feed, and the liberated aluminum halide is passed in admixture with the purified hydrocarbon feed to the conversion zone.

U.S.P. 2,465,279. Ferro-Ferric Oxide-Alkali Metal Trioxalato Ferriate Catalyst and Process of Preparation. J. C. Schiller to Standard Oil Development Company.

A Fischer-Tropsch synthesis catalyst is prepared from a mixture of 80-99.8 percent ferro-ferric oxide and 20-0.2 percent of an alkali metal trioxalato ferriate. The mixture is heated at about 1000° F. in the presence of a free oxygen containing atmosphere for about 4 hours. Subsequently the mixture is contacted with a reducing atmosphere at about 700° F. for 24 hours. During synthesis, heavier hydrocarbons are obtained by use of this catalyst for a long on-stream period.

U.S.P. 2,465,280. Alpha Iron Oxide-Alkali Metal Trioxalato Ferriate Catalyst and Process of Preparation. J. C. Schiller to Standard Oil Development Company.

The process of this patent differs from that of U. S. patent 2,465,279 essentially only in that alpha iron oxide is employed in place of the ferro-ferric oxide.

U.S.P. 2,465,281. Gamma - Iron Oxide-Alkali Metal Trioxalato Ferriate Catalyst and Process of Preparation. J. C. Schiller to standard Oil Development Company.

Gamma iron oxide is employed here instead of the alpha iron oxide in a process otherwise identical with that of U. S. patent 2,465,280.

U.S.P. 2,465,282. Alkali Metal-Trioxalato Ferriate Catalyst and Method for its Preparation. J. S. Schiller to Standard Oil Development Company.

Iron oxide is employed here instead of the ferro-ferric oxide in a process otherwise identical with that of U. S. patent 2,465,279.

U.S.P. 2,465,313. Alpha Iron Oxide-Alkali Metal Pyroantimoniate Catalyst and Process of Preparation. M. A. Mosesman to Standard Oil Development Company.

The alkali metal trioxalato ferriate of the process of U.S.P. 2,465,280 is here replaced by an alkali metal pyroantimoniate in an otherwise identical process.

U.S.P. 2,465,314. Gamma Iron Oxide-Alkali Metal Pyroantimoniate Catalyst and Process of Preparation. M. A. Mosesman to Standard Oil Development Company.

The process according to this patent corresponds to that of U.S.P. 2,465,281 in the same manner as U.S.P. 2,465,313 corresponds to U.S.P. 2,465,280.

U.S.P. 2,465,315. Ferro - Ferric Oxide-Alkali Metal Pyroantimoniate Catalyst and Process of Preparation. M. A. Mosesman to Standard Oil Development Company.

The process of this patent corresponds to that of U.S.P. 2,465,279 in the same manner as U.S.P. 2,465,313 corresponds to U.S.P. 2,465,280.

U.S.P. 2,466,046-9. Preparation of Clay Catalysts. H. A. Shabaker, G. A. Mills and R. C. Denison to Houdry Process Corporation.

A clay containing iron compounds is treated at a temperature of at least 1200° F. and below a temperature sufficient to effect incipient fusion of the clay, with a chemical reagent in gaseous form, reactive with iron, to form acid soluble iron salts. The treated clay is leached after cooling to remove these salts and then calcined. Hydrocarbon conversion catalysts are obtained.

According to U.S.P. 2,466,047, acid-activated montmorillonite clay is subjected to this method, the leaching being preferably accomplished by acids.

According to U.S.P. 2,466,048, the iron-containing clay is contacted under suitable conditions with H_2S.

According to U.S.P. 2,466,049, chlorine is employed for the same purpose.

U.S.P. 2,466,052. Preparation of Clay Catalysts. H. A. Shabaker, G. A. Mills and R. C. Denison to Houdry Process Corporation.

The process according to this patent substantially resembles those of U.S.P. 2,466,046-9. CS_2 is employed here for the treatment of the clay at a temperature of at least 1300° F.

CRACKING AND REFORMING

U.S.P. 2,464,257. Pyrolytic Conversion of Hydrocarbons. H. L. Pelzer and K. M. Watson to Sinclair Refining Company.

Hydrocarbon vapors are repeatedly passed transversely through a solid column of downwardly moving hot catalyst at progressively different elevations. The effluent vapors are fractionated and a resulting insufficiently cracked fraction is further cracked in the same manner in a different zone of the reaction chamber.

U.S.P. 2,466,005. Cracking with a Contact Mass. J. A. Crowley, Jr. to Socony-Vacuum Oil Company, Inc.

In the thermal cracking of hydrocarbons at high temperature and controlled reaction time two continuously moving beds of granular solid heat transfer agent are provided, one above the other. The lower bed is supplied at its upper surface with highly heated granules while cold granules are supplied to the upper bed. The hydrocarbon charge is admitted to the bottom of the lower bed and passes countercurrent through both ends. Prompt quenching of the reaction effluent is accomplished in the upper bed.

U.S.P. 2,466,050. Process of Hydrocarbon Conversion with a Pretreated Montmorillonite Clay Catalyst. H. A. Shabaker, G. A. Mills and R. C. Denison to Houdry Process Corporation.

A montmorillonite clay catalyst treated according to U.S.P. 2,466,047 is employed for catalytically cracking hydrocarbon oil to form gasoline hydrocarbons of improved value as motor fuel. The pretreated catalyst employed shall not contain more than .4 percent Fe_2O_3.

U.S.P. 2,466,051. Process of Hydrocarbon Conversion with a Pretreated Kaolin Clay Catalyst. H. A. Shabaker, G. A. Mills and R. C. Denison to Houdry Process Corporation.

The process according to this patent differs from that of U.S.P. 2,466,050 only in that instead of the pretreated montmorillonite a kaolin clay pretreated in the same manner is employed.

U.S.P. 2,466,334. Method of Producing Synthetic Fuel. W. E. Skelton to The Texas Company.

Details are claimed of a process for the manufacture of high octane aviation gasoline, particularly of so-called superfuel, from the cracking product of hydrocarbon oil.

ALKYLATION

U.S.P. 2,464,291. Stabilization of Organic Compounds. J. A. Chenicek to Universal Oil Products Company.

A product formed by the reductive alkylation of p-phenylene diamine with an aliphatic unsaturated ketone is employed as an inhibitor for stabilization against oxydation of cracked gasoline.

U.S.P. 2,465,049. Alkylation of Hydrocarbons. I. L. Wolk to Phillips Petroleum Company.

In the alkylation of hydrocarbons in the presence of concentrated H_2SO_4 the acid-water ratio of the catalyst is maintained at a predetermined value by continuous introduction of sufficient SO_3 to react with all the water introduced with the reactants to form H_2SO_4. Details for the manner of introduction of the SO_3 into the reaction mixture are given.

U.S.P. 2,465,610. Production of Alkylated Aromatic Compounds. H. N. Short and F. Olmsted to Shell Development Company.

A gaseous fraction of hydrocarbon cracking products containing a mixture of an olefin and the corresponding paraffin is contacted with a mixture of an aromatic hydrocarbon, such as benzene, and a compound miscible therewith in which the olefin has a greater solubility (e.g. nitrobenzens). An absorption product is thus obtained which contains a higher ratio of the olefin to corresponding paraffin than the gaseous feed. The absorption product is distilled to separate the miscible compound therefrom. The resulting mixture of the olefin and aromatic hydrocarbon is catalytically alkylated.

ISOMERIZATION

U.S.P. 2,464,201. Isomerization of Hydrocarbons and Improved Catalysts Therefor. J. W. Latchum, Jr. to Phillips Petroleum Company.

Vapors of a saturated hydrocarbon (e.g. butane) containing a vaporized Friedel-Crafts type metal halide, as obtained in the isomerization of saturated n-hydrocarbons by metal halides, are contacted with a solid acid salt of a polybasic acid having a replaceable hydrogen atom, such as N_aHSO_4, under conditions effecting adsorption of the metal halide by this acid salt. The material thus produced is utilized as a catalyst for further isomerization of saturated hydrocarbons.

POLYMERIZATION AND CONVERSION

U.S.P. 2,464,205. Catalysis of Hydrocarbons. J. R. Bates to Houdry Process Corporation.

A hydrocarbon charging stock is subjected at reaction temperature to the action of a catalyst obtained by base exchanging a zeolite produced by drying a hydrous coprecipitate of silica, alumina and beryllia containing alkali metal, with an ammonium or amino salt solution, and by heat treatment of the base exchanged zeolite to remove residual ammonium or amino cation. High yields of valuable products, e.g. high anti-knock stable motor fuels from a cracking operation, result from the use of these catalysts.

U.S.P. 2,464,266. Pyrolytic Conversion of Hydrocarbons. E. W. Shaud to Sinclair Refining Company.

Catalyst and liquid hydrocarbon oil are ground together under super-atmos-

Solving New Corrosion Problems

Operating Tests Show Superiority of Copper and Its Alloys

Intensive research in the chemical and petro-chemical fields continues to bring forth new and important products which call for improvements in existing plants plus a tremendous expansion program.

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Pilot Plant Testing Recommended. Since new products and new methods bring new problems in corrosion, much can be done to gauge the performance of materials before specifying them for new installations. Trying out various metals in the pilot plant stage rather than in the laboratory is advisable in order to duplicate as nearly as possible actual operating conditions. This is necessary because the introduction of traces of other materials into a relatively pure chemical as used in laboratory tests can often lead to marked changes in corrosion behavior.

Bridgeport Laboratory will be glad to cooperate along these lines by submitting sample lots of single-walled tubing, duplex tubing or test coupons for observation since much experimental work of an exploratory nature must be undertaken on products and combinations of chemicals whose behavior is not known.

Advantages of Copper and Its Alloys. Since the objective of chemical engineers is to operate their plants on a continuous basis, materials both of a reliable nature and moderately priced must be used to make this practical. Low maintenance, minimum of shutdowns, and prevention of contamination are obtained under most operating conditions from copper-base alloys which have the following characteristics:

1. Good corrosion resistance.
2. Mechanical strength to withstand the necessary working pressures.
3. High heat transfer properties, maintained for long periods without loss of efficiency.

The corrosion resistance of copper and copper-base alloys in fresh water, sea water, numerous liquids and gases, and atmospheres accounts for their wide use in such media. Not only are they moderate in cost but their ease of fabrication makes them well suited for applications requiring cold or hot working in the performance of fabricating operations, such as bending, forming, spinning, cupping, stamping and deep drawing. From a heat conductivity standpoint, copper has the highest value among commercial metals. For these reasons copper and its alloys are the first choice for use in the construction of heat exchangers, condensers, water heaters, radiators, air conditioning and refrigerating equipment, kettles, etc.

Mechanical Properties Retained at Low Temperatures. The addition of alloying elements, such as zinc, nickel, tin, aluminum, and silicon, increase the strength and hardness of copper. The effect on corrosion resistance varies with the environment.

Fabricating Lubricating Oil Coolers — Courtesy Condenser Service and Engineering Co., Inc., Hoboken, N. J.

Copper and its alloys, however, lose a substantial portion of their mechanical properties values at temperatures above 600°F, which limits their use to operations in the higher temperature field. On the other hand, copper-base alloys retain most of their excellent physical properties at sub-atmospheric temperatures, which cause many ferrous alloys to become brittle. This is of particular importance in selecting materials for handling, at low temperatures, gases such as oxygen, nitrogen, hydrogen, carbon dioxide, air, etc., in liquid form. Copper and its alloys are performing well in such low temperature work as dewaxing, and handling and storing of refrigerants.

We would like the opportunity of working with engineers of chemical and petro-chemical plants on their maintenance and corrosion problems. Contact the nearest Bridgeport sales office. Write for Condenser Tube Manual and Duplex Tubing Technical Bulletin No. 746.

• • •

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CONDENSER AND HEAT EXCHANGER TUBING

pheric pressure in the presence of a wetting agent, such as lecithin. The hydrocarbon oil is then vaporized by pressure reduction. The resulting vapors with the catalyst suspended therein are passed to a hydrocarbon conversion zone. Catalysts dispersed and suspended in this manner show little tendency to drop out of suspension.

U.S.P. 2,464,489. Method for Hydrocarbon Conversion. J. A. Crowley, Jr. to Socony-Vacuum Oil Company, Inc.

The patent relates to a continuous cyclic hydrocarbon conversion process wherein finely divided contact material is moved through the conversion zone, contacted therein with gaseous or vaporized hydrocarbon oil, and then moved through a regeneration zone. Details are claimed of this process and of the method of preparing the hydrocarbon oil charge.

U.S.P. 2,464,616. Catalytic Hydrocarbon Conversions. E. F. Schwarzenbek and J. W. Moorman to The M. W. Kellogg Company.

In a continuous catalytic hydrocarbon conversion process, the finely divided spent catalyst is introduced into the regeneration zone in admixture with a relatively inert finely divided solid, the particles of which have settling rates lower than the settling rates of the active catalyst. The regenerating gas is passed upwardly through this zone at a velocity to maintain two distinct phases of suspended solid particles, including a lower dense turbulent catalyst phase and an upper light diffuse phase mainly containing suspended inert solids. The combustion gas is withdrawn from the portion of the zone containing the diffuse phase. Solids separated from this combustion gas are returned to the lower dense phase of the regeneration zone. Solids separately withdrawn directly from this lower dense phase are transferred to the hydrocarbon conversion zone.

U.S.P. 2,464,742. Synthetic Elastomers from Branch-Chain Hexadiene Copolymers. E. T. Bishop to Shell Development Company.

5-20 percent of an open-chain 1, 3-diene hydrocarbon of 4-5 C atoms are copolymerized with 95-80 percent of a mixture consisting of 85 percent 2-methyl-1, 3-pentadiene and 15 percent 4-methyl-1, 3-pentadiene in the absence of any other polymerizable compound. Elastomers are obtained.

U.S.P. 2,464,810. Catalytic Conversion. J. H. Hirsch and K. E. Cody to Foster Wheeler Corporation.

Hydrocarbon oil of low hydrogen content is dissolved in a naphtha solvent. At least a portion of this solution is contacted with a hot catalyst for vaporization. The hot catallyst and vapor are then passed into a reaction zone where carbon is deposited on the catalyst. Vaporous conversion products obtained are fractionated to remove a naphtha fraction at least a part of which is used as the solvent.

U.S.P. 2,464,812. Catalytic Conversion System. E. A. Johnson to Standard Oil Company (Indiana.)

Details of a method are claimed for separately contacting solids of small particle size with a plurality of different gasiform streams in two separate contacting zones located adjacent each other. The method eliminates the use of valves in the conduits handling the powdered catalyst.

U.S.P. 2,465,020. Process for Treating Materials with a Volatile Treating Agent. H. H. Jones to Phillips Petroleum Company.

In the catalytic conversion (e.g. isomerization) of hydrocarbons by passing them through a continuous unobstructed bed of Friedel-Crafts metal halide catalyst supported on contiguous particles of solid adsorbent material, a gaseous stream comprising a carrying gas and metal halide vapors is introduced at a plurality of points spaced along the length of the bed to uniformly impregnate it with additional fresh metal halide.

U.S.P. 2,465,122. Resinous Copolymers of Styrene and 2,5,2',5'-Tetrachloro-4,4'-Divinyl-Biphenyl. F. Rosenthal to Radio Corporation of America.

A resinous copolymer is obtained from styrene by heating it to polymerization temperature with 1-3 percent (of its weight) of 2,5,2',5'-tetrachloro-4,4' divinyl-biphenyl. The copolymers produced have improved heat resistance.

U.S.P. 2,465,255. Hydrocarbon Conversion Process. J. W. Moorman to The M. W. Kellogg Company.

Details of a process are claimed for converting hydrocarbons by contacting their vapors with a finely divided catalyst and for regenerating the spent catalyst in a dilute suspension in hot gaseous products of combustion.

U.S.P. 2,465,363. Production of Synthetic Elastomers. W. F. Faragher and J. W. Harrison to Houdry Process Corporation.

A conjugated diolefin with 4-6 C atoms is polymerized in aqueous emulsion in a tublar reaction zone at a temperature of 100-175° C. while the deposition of polymer on the walls of the reaction zone is prevented by reciprocating flow of the emulsion in this zone. A rubbery products is obtained.

U.S.P. 2,465,888. Butadiene Emulsion Polymerization in the Presence of Levopimaric Acid-Maleic Anhydride Addition Product Esters. R. V. Lawrence to the U. S. Secretary of Agriculture.

A butadiene-1,3 hydrocarbon is copolymerized in aqueous emulsion with an organic compound having ethylenic unsaturation (e.g. styrene) in the presence of an alkali salt of an alkyl ester of the addition product of levopimaric acid and maleic anhydride. A synthetic rubber of improved tensile strength, increased elongation and improved milling characteristics and tack is formed.

U.S.P. 2,465,901. Butadiene Emulsion Polymerization in the Presence of Levopimaric Acid-Maleic Anhydride Addition Product. F. L. McKennon and R. V. Lawrence to the U. S. Secretary of Agriculture.

The process of this patent is closely related to that U.S.P. 2,465,888. A soap is here employed as the emulsifying agent.

U.S.P. 2,466,212. Polymerization of Conjugated Diolefins and Vinyl Compounds. J. D. Danforth to Universal Oil Products Company.

Isoprene, butadiene-1,3, styrene, or alpha-methyl styrene or a mixture of butadiene-1,3 and styrene are emulsion polymerized in the presence of an aqueous phase containing 1-50 percent by weight of a partial ester formed from a fatty acid with 10-20 C atoms and a water soluble poly-oxyalkylene derivative of a hexitol or its anhydride. The partial ester has the effect of a dispersing and wetting agent.

DESULFURIZATION

U.S.P. 2,464,520. Process for Desulfurizing an Aromatic Hydrocarbon Containing Thiophene. A. P. Lien and B. L. Evering to Standard Oil Company (Indiana).

An aromatic hydrocarbon containing thiophene is contacted with at least 30 percent by volume of anhydrous liquid HF. H_2S is generated and a resin derived from thiophene and an aromatic hydrocarbon is produced. Sufficient liquid HF is maintained in the reaction zone to disperse the resin and to form a distinct liquid phase. The reaction mixture is allowed to stratify, and a desulfurized and deresined aromatic hydrocarbon layer is separated from a layer of liquid HF containing the resin.

U.S.P. 2,464,576. Process for the Removal of Mercaptans from Petroleum Distillates with an Aqueous Alkaline Reagent Containing Lignin and the Regeneration of the Spent Alkaline Reagent. R. R. Hibbard and F. Veatch to The Standard Oil Company (Ohio).

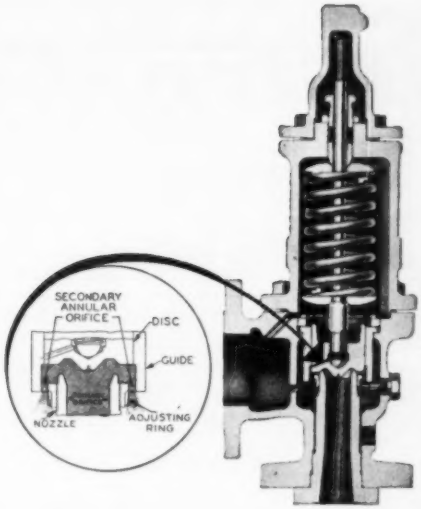
A liquid mercaptan-containing hydrocarbon distillate is contacted with an aqueous alkaline reagent containing dissolved lignin. The mercaptan reduction of the hydrocarbons is effectively increased by the presence of lignin in the alkaline solution.

U.S.P. 2,465,964. Treatment of Cracked Petroleum Distillates. L. F. Brooke, M. M. Holm and L. P. Elliott to California Research Corporation.

Sulfur compounds are selectively removed from cracked petroleum distillate containing them and having a substantial content of mono-olefinic and aromatic hydrocarbons of high antiknock value by extracting the distillate with aqueous HF of 70-90 percent concentration. Two phases are formed, the acid extract phase containing sulfur compounds. The hydrocarbon raffinate phase has a substantially reduced sulfur content. The water content of the aqueous HF in the extraction is adjusted within the specified range to produce a substantially unsaturated raffinate comprising the major proportion of the mono-olefinic and aromatic hydrocarbons of the starting material.

U.S.P. 2,466,336. Production of Sulfur Trioxide. L. C. Strang to Anglo-Iranian Oil Company, Ltd.

A normally liquid petroleum fraction



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Field adjustments cannot alter the rated capacity of a CONSOLIDATED Safety Relief Valve.

The single ring blow-down adjustment controls blow-down only. Blow-down adjustment is not dependent upon multiple rings and cannot affect lift and capacity by disturbing the area of the secondary annular orifice. These fixed secondary orifice dimensions cannot be accidentally altered during maintenance. CONSOLIDATED is a truly "capacity safe" safety valve.

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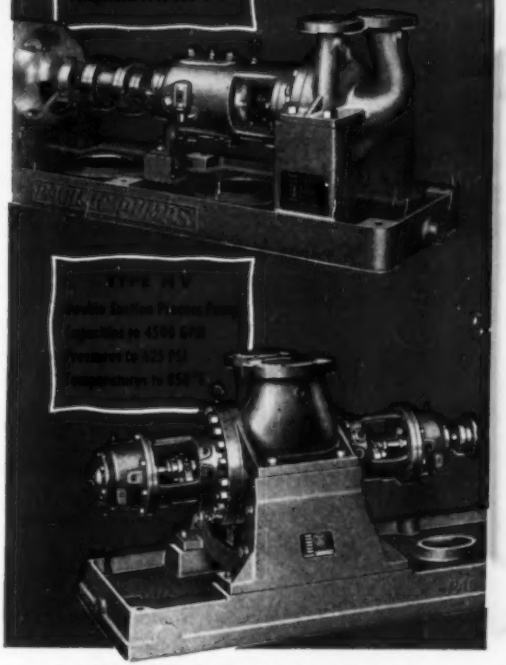
This could be repeated many more times—but there are only 26 letters in the alphabet.



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WHICH ADVANTAGE

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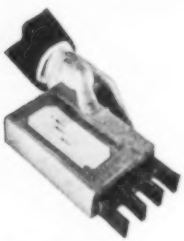

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4 Non-slip Twisted Cross-Bar?

5 Self-cleaning—no sharp corners to clog?

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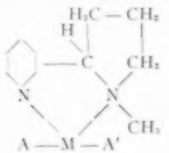
Patents

containing sulfur compounds is subjected to catalytic hydrogenation in the presence of free hydrogen to convert the combined sulfur to H_2S. The resulting gas essentially consisting of H_2S, H_2 and CH_4 is burnt in the presence of air to yield a gaseous mixture containing SO_2 and a large excess of oxygen. The SO_2 in this mixture is then catalytically converted to SO_3. Details of this process are claimed.

HEAVY OILS AND WAXES

U.S.P. 2,464,497. Mineral Oil Composition. J. J. Giammaria to Socony-Vacuum Oil Company, Inc.

A viscous mineral lubricating oil fraction contains as a stabilizer against oxidation 0.1-5 percent of an oil-soluble coordinated metal complex of the general formula:



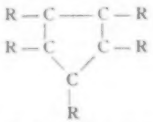
wherein M is Cu, Hg, Al, Pb, Co, or Ni; and A and A′ are organic acid groups. Other organic bases with two tertiary nitrogen atoms in 1,5 relationships as typified by nicotine can be substituted for that described above.

U.S.P. 2,464,759. Water-Repellent Coating Composition and Method of Coating. T. P. Camp to United States Gypsum Company.

A water-repellent non-wettable coating composition, particularly for cementitious materials, consists of one part of paraffin wax and 4-10 parts of a petroleum base asphalt of 110-185° F. melting point. The wax is dispersed in a continuous phase of asphalt in the form of minute discrete particles.

U.S.P. 2,465,292. Chemical Process. W. J. Sparks and D. W. Young to Standard Oil Development Company.

To form a lubricant, a hydrocarbon substance is compounded with 0.1-15 percent of a product dissolved therein and obtained by the reaction of P_2S_5 and a homopolymer of a compound of the formula

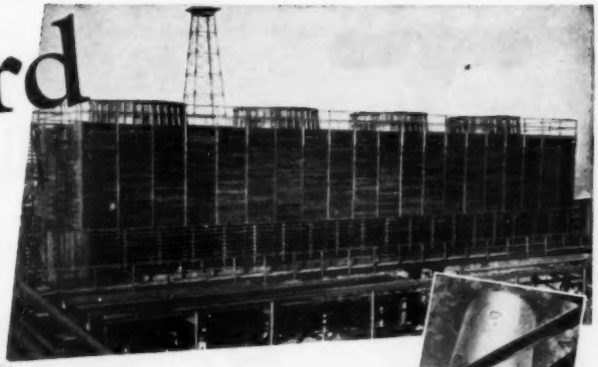


wherein R is hydrogen or a saturated aliphatic hydrocarbon with ⅛ C atoms. This reaction is carried out at a temperature of 75-130° C. for a time sufficient to combine 0.1-15 percent of P and S with the polymer. The additive has high thickening power, an improved viscosity index, and extreme pressure properties.

U.S.P. 2,465,335. Insecticidal Spray Oil Containing Lecithin. M. J. Burkhard to Socony-Vacuum Oil Company, Inc.

A spray oil for use in verdant spraying comprises a moderately refined pe-

Pritchard COOLING TOWERS



Pritchard's patented SEALD-FLOW unitized self-ventilating fan drive, available on new towers or as replacement units on any make of tower.

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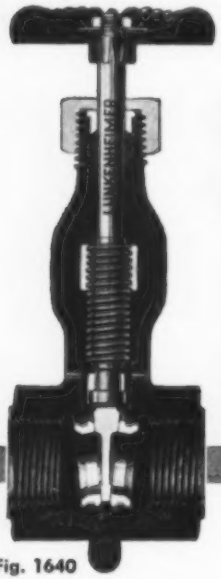

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with LUNKENHEIMER "KING-CLIP" VALVE

Fig. 1640

The Lunkenheimer "King-Clip" Valve has one quality feature after another... from the coarse, heavy stuffing box threads and hex-head gland which minimize stuffing box troubles... to the heavy body which resists wrenching and piping strains... and the heavy rust-proofing treatment, inside and out. Each feature adds longer life, lower maintenance and better service, wherever small and medium sized gate valves are used.

Note the ample, unobstructed drain channels and bronze thread bushing, features originated by Lunkenheimer, as was the "King-Clip" Valve itself. The Lunkenheimer "King-Clip" Valve is truly the king of all clip type valves... widely used for more than 50 years and, today, better than ever for longer, low-cost service.

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Manifold employing multiple Lunkenheimer "King-Clip" Gate Valves. Note the compactness of the installation and the convenience of the bolted bonnets, each of which is readily accessible. "King-Clip" Gate Valves are furnished in 21 standard types, with iron body-bronze trim, all-iron or iron body-alloy trims and with inside or outside rising stems for various service needs.

ASK YOUR DISTRIBUTOR

Consult your valve specialist, the friendly near-by Lunkenheimer Distributor. He has a stock of "King-Clip" Valves as well as other fine Lunkenheimer products. Ask for Bulletin 561 which details the 21 standard types of "King-Clip" Valves.

Patents

troleum oil of 50-150 seconds Saybolt viscosity at 100° F. having an unsulphonatable residue not over 80 percent and 0.05-1 percent by weight of lecithin.

U.S.P. 2,465,902. Stabilized Liquid Petroleum Hydrocarbon. J. G. McNab and D. T. Rogers to Standard Oil Development Company.

A mineral lubricating oil, or the like, contains for stabilization a small amount of a dissolved product obtained by reacting a phosphorus sulfide with a polyvalent metal salt of a compound of the formula $Ar(OH)(SO_3H)(R)$ where Ar is an aromatic nucleus with not more than 12 C atoms and R is an alkyl group of sufficient length to impart oil solubility to the reaction product.

U.S.P. 2,465,961. Grease. H. van Olphen to Shell Development Company.

A grease composition comprises a major amount of lubricating oil, an amount of metallic soap sufficient to gel the oil and form a grease structure, and 1-10 percent of an oil soluble monomeric glycol with at least 6 C atoms, such as catene glycol.

U.S.P. 2,466,408. Lubricating Composition. C. E. Funk, Jr. to American Cyanamid Company.

An oil-soluble diester of dithiophosphoric acid is added to a dispersion in mineral oil of an oxide or hydroxide of Ca or Zn. The dispersion shall contain 0.1-5 percent of water. The mixture is heated to 20-90° C., whereupon the oil-insoluble reaction salts are removed. In the use of the resulting composition for lubricating internal combustion engines, etc., the formation of sludge or varnish is inhibited.

U.S.P. 2,466,647. Lubricating Oil Composition. R. Stern to Shell Development Company.

The emulsifiable oil composition comprises a hydrocarbon oil, an organic oil-in-water emulsifier, and 0.1-5 percent of an organic polyalkyl tripolyphosphate ester, e.g. monosodium pentacapryl tripolyphosphate. Detergency and anti-wear effect of the composition is improved by the polyphosphate additive, while corrosiveness to iron, cadmium and other metals is reduced and the emulsion is materially stabilized thereby. The composition is particularly suitable as a grinding and cutting oil.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,464,271. Coal Liquefaction by Hydrogenation. H. H. Storch and L. L. Hirst to the Secretary of the Interior.

The details of a process for producing fuel oil directly from coal are claimed, wherein a mixture of powdered coal and heavy recycle oil is treated at high pressure and evelated temperature in the presence of small amounts of a mixture of tin sulfide and iodide.

U.S.P. 2,464,480. Hydrocarbon Synthesis. R. A. Beck, E. E. Sensel and A. J.

SQUEEZING THE LAST DROP.....

▲ Shown above is the recently added LPG system that is "squeezing the last drop" from what was formerly fuel gas in this refinery.

The BARECO refinery at Wichita, Kansas processing crude at the rate of 6,500 b/d had an excess of propane residue being burned as plant fuel.

Installation of a new LPG processing unit, designed and constructed by Born Engineering Company, recovers better than 125 barrels of propane daily which not only "squeezes the last drop" but shows an excellent return on the investment.

If you are thinking of modernizing your refinery or natural gasoline plant, a Born engineer can show you the efficient, economical way to do it.

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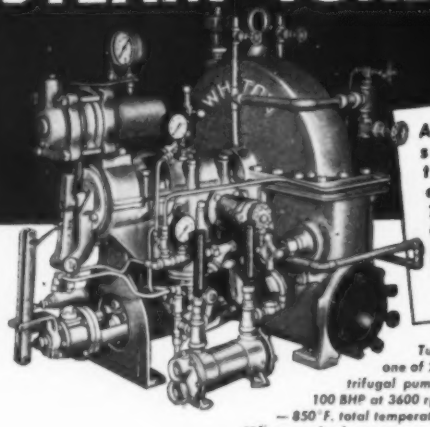
Canadian Associates: BRANDON, MANITOBA, Canadian Brown Steel Tank Co., Ltd.

Whiton SOLID STEEL ROTOR

STEAM TURBINES



Available in single stage types up to approximately 1200 HP rating. Center supported frames are available when required.

Turbine shown above is one of 24 ordered to drive centrifugal pumps designed to deliver 100 BHP at 3600 rpm with steam at 850° — 850° F. total temperature exhausting against 42# gauge back pressure.

• **SIMPLE DESIGN FOR ACCESSIBILITY**

Inlet and exhaust connections are located in lower half of casing which is horizontally split to allow easy access to all internal parts. Rotating unit including bearings and governor head may be removed without disturbing alignment of the unit.

• **RUGGED CONSTRUCTION FOR RELIABILITY**

Whiton rotors are made from a solid steel forging with semi-circular buckets milled in the rim to give strength where it is needed. End thrust is minimized because the path of the steam is always at right angles to the shaft.

• **SAFETY DEVICES FOR TROUBLE-FREE OPERATION**

Standard equipment includes Constant Speed Governor with V-Ported Governor Valve . . . Emergency Governor with Independent Valve . . . Steel Plate Steam Strainer . . . Two oil rings per bearing supplemented by water cooling . . . Sentinel Type Casing Relief Valve . . . Additional accessories available as required.

THOUSANDS OF SATISFACTORY INSTALLATIONS SINCE 1911

Write for complete information

WHITON MACHINE COMPANY
NEW LONDON, CONN., U.S.A.
also makers of Fine Lathe Chucks • Gear Cutting Machines • High Production Milling Machines • Centering Machines

Patents

Millendorf to The Texas Company.

In the synthesis of hydrocarbons from CO and H_2 in the presence of a catayist containing a minor amount of alkali metal to favor the production of normally liquid hydrocarbons, this selectivity of the catalyst is maintained during use by supplementing the alkali metal content and increasing the reaction temperature as the selectivity tends to decline.

U.S.P. 2,464,501. Catalytic Synthesis of Hydrocarbons. J. H. Grahame to The Texas Company.

Synthesis gas of high temperature is cooled by contact with a hydrocarbon conversion catalyst until this catalyst reaches conversion temperature. The synthesis gas is then contacted under reaction conditions with a hydrocarbon synthesis catalyst. The resulting hydrocarbons (or a portion thereof) are contacted with the hot conversion catalyst withdrawn from the cooled synthesis gas, and converted hydrocarbons are recovered. Normally gaseous hydrocarbon products are recycled to the synthesis catalyst.

U.S.P. 2,464,505. Method of Producing Gasoline. C. E. Hemminger to Standard Oil Development Company.

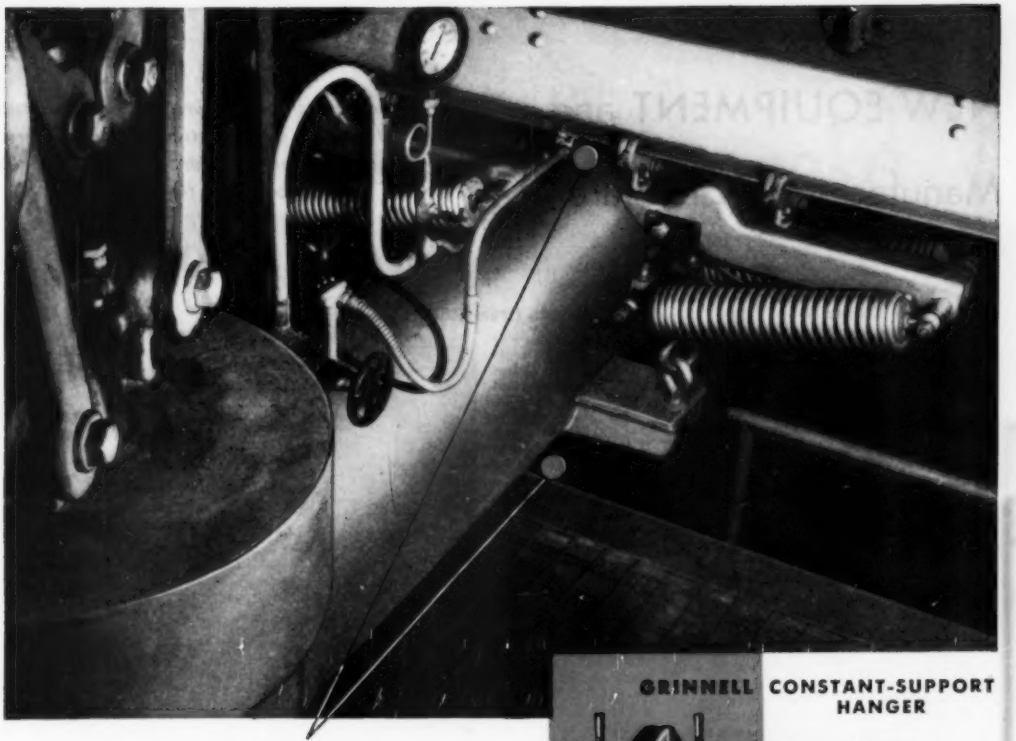
A suspension of powdered iron catayst in a CO-H_2 stream is flowed through an elongated reaction zone at a velocity such that the flow of catalyst and gases within this zone is substantially concurrent and the residence time of both is not substantially in excess of 20 seconds. A temperature gradient of from 550° F. at the inlet to 700-750° F. at the outlet of the zone is maintained.

U.S.P. 2,464,532. Catalytic Synthesis of Hydrocarbons. F. B. Sellers to Texaco Development Company.

The process of this patent is to a certain extent related to that of U.S.P. 2,464,501. In the present case the hot synthesis gas is continuously passed in heat transfer relationship with a solid particle, heat absorptive thermophore having solid carbonaceous deposits as a result of hydrocarbon conversion. The thermophore is thus heated to a temperature at which the deposits are reactive with an oxidizing gas such as water vapor or CO_2. By regenerating the theromophoric material in this manner, additional amounts of synthesis gas constituents are formed which can be mixed with the first-named synthesis gas to be employed for the production of hydrocarbons and oxgenated hydrocarbons, while the regenerated thermophore can be employed for further hydrocarbon conversion.

U.S.P. 2,465,016. Process for Catalytic Dehydrogenation. F. E. Frey to Phillips Petroleum Company.

C_3-C_5 paraffins and olefins to be dehydrogenated are mixed with benzene. The mixture is heated to a temperature of 1000-1300° F. to obtain non-catalytic dehydrogenation of the aliphatic hydrocarbons in an amount of 5-15 percent by volume. The effluent of this reaction is then repeatedly treated with a large mass of particulate solid dehydrogenation catalyst under varying conditions.



PLAYROOM for a HEAVYWEIGHT

It's a lively chunk of deadweight, this big boiler lead from a superheater outlet at the stop and check valve . . . in the new Southwark station of the Philadelphia Electric Company. It requires "playroom". From its position when cold to its position at 900°F., this piping travels through all three planes — vertical, lateral and longitudinal.

At every point of its travel, the weight of this piping is fully supported by Grinnell Constant-Support Hangers. Yet, because of their compact design, little extra "playroom" need be allowed in which to install the hangers.

Write for the new Grinnell Pipe Hanger Catalog 10-D, containing every pipe hanger, part and accessory, with full instructions for easy selection and correct specification.

GRINNELL CONSTANT-SUPPORT HANGER

the ONLY constant-support pipe hanger

- provides constant support to piping subject to vertical movement — in all "hot" and "cold" positions.
- maintains full safety factor in supporting high temperature, high pressure piping.
- non-resonant and energy absorbing.
- mass-produced from standard precision parts.
- individually calibrated for each installation.
- load-adjustment features incorporated into design.
- three models meet entire range of load-travel specifications.
- minimum headroom required.

99 YEARS PIPING

GRINNELL

Grinnell Company, Inc., Providence, R. I. Branch warehouses: Atlanta • Buffalo • Charlotte • Chicago • Cleveland • Cranston • Fresno • Kansas City • Houston Long Beach • Los Angeles • Milwaukee • Minneapolis • New York • Oakland • Philadelphia • Sacramento • St. Louis • St. Paul • San Francisco • Seattle • Spokane

NEW EQUIPMENT and Manufacturers' Literature

For copies of manufacturers' literature or more information on products described on these pages write to the address shown, using the number shown for each item.

Metal Filter Cloths (Item 260)

Michigan Wire Cloth Company has in stock two types of sample kits of wire cloth and metal filter cloth. One kit contains samples of square mesh wire cloth from 10 to 120 mesh in monel, brass, aluminum and copper. The filter cloth kit has samples from 40 to 700 mesh in nickel, monel, brass, chromel and stainless steel. Weaves include plain, twilled, plain dutch and twilled dutch.

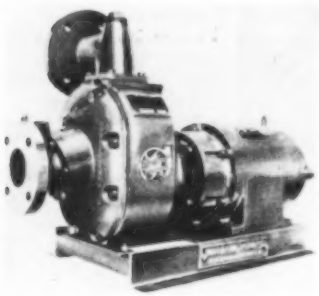
For further information write Michigan Wire Cloth Company, 2100 Howard Street, Detroit 16, referring to PETROLEUM REFINER 260.

Ammeter, Voltmeter (Item 261)

With five current ranges up to 1000 amperes and three voltage ranges up to 700 volts, the new a-c clamp ammeter and voltmeter, introduced by Weston Electrical Instrument Corporation, is designed "to measure alternating currents and voltages without interrupting electrical service." Current measurements are made by placing a rubber insulated, trigger-operated clamping jaw around the conductor. Voltage measurements are made by connecting a set of clip-on voltage leads to the line and to the screw type terminals recessed in the side of the meter. The model has a claimed rated accuracy within three percent of the full scale range when used on frequencies between 50 and 70 cycles.

For further information write Weston Electrical Instrument Corporation, 617 Frelinghuysen Avenue, Newark 5, N. J., referring to PETROLEUM REFINER item 261.

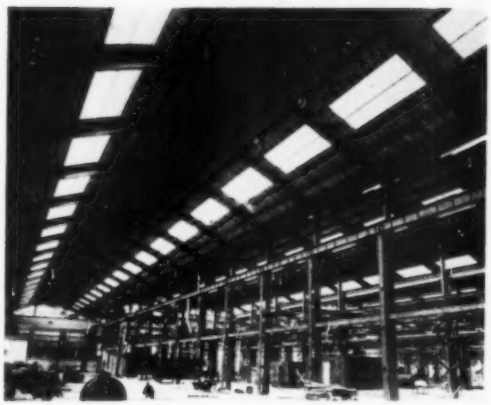
Centrifugal Pumps (Item 262)



Marlow Pumps has expanded its basic series of self-priming centrifugal pumps to 26. Included in the series are electric horizontal long-coupled and vertical and horizontal close-coupled models, portable and stationary engine-driven models and belt-driven models. All of the pumps feature free-flow design, the "diffuser" method of priming allowing the pump to prime automatically, and contain no by-pass valves or other mechanical devices. Liquids with viscosities up to 500 S.S.U. can be pumped. Capacity ranges from 50 to 250 gallons per minute in close-coupled construction.

For further information write Marlow Pumps, Ridgewood, N. J., referring to PETROLEUM REFINER item 262.

Plastic Sheets (Item 263)



Alsynite, translucent plastic sheets made of Fiberglas mat impregnated with Laminac resin, is manufactured by Allied Synthetics Company. Weighing approximately eight ounces per square foot, the sheets "can be sawed and nailed with ordinary tools, punched or drilled and fastened in place with ordinary sheet metal screws or bolts." For weatherproofing lap joints, a translucent mastic is provided. Corrugations are claimed to correspond to those of standard corrugated metal and can be installed without framework of any kind. With flat corrugations, the sheets are available in 8 to 10 foot lengths, in 4 inch increments. Width is 26 inches. The sheets can also be supplied with curved corrugation. It is claimed the sheets will not shatter or rot, are unaffected by climatic conditions, will not readily ignite or support combustion. The photograph shows the use of Alsynite in the new plant of National Tank Company in Dallas.

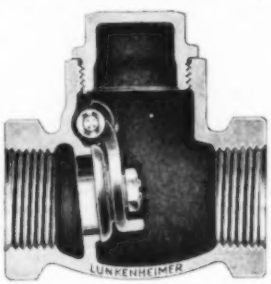
For further information write Allied Synthetics Company, San Diego, Calif., referring to PETROLEUM REFINER item 263.

Mineral Insulation (Item 264)

Federal Specifications HH-I-563 has been issued by the government on the performance of mineral wool insulation on high temperature equipment. Mineral wool blankets, felts and industrial batts are classified by temperature limit ranges up to 500°, 1000° and 1200° F. General requirement limitations include non-fibrous content, corrosiveness, moisture adsorption, temperature resistance, fire resistance and thermal conductivity. Detail requirements include construction of the three product forms and specifications of their respective densities.

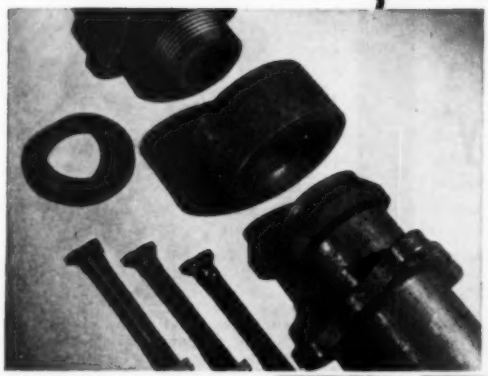
For a copy write Industrial Mineral Wool Institute, 441 Lexington Avenue, New York 17, referring to PETROLEUM REFINER item 264.

Swing Check Valve (Item 265)



Cutaway illustrations as well as leading dimensions of the improved line of 125 pounds S. P. bronze globe, angle and check valves of The Lunkenheimer Company are shown in Circular 582. The swing check valve has two renewable side plugs which serve as bearings for the disc carrier pin. Misalignment of the carrier pin can be corrected by renewing the side plugs. The plugs also

How to make "Karbate" pipe connections



1. A "Karbate" flexible coupling ready for assembly. Note rubber gasket covering serrations on right hand pipe, ¼" from end. Gasket lying on table will be similarly applied over serrations on left hand pipe.

2. Flexible coupling being tightened in place.

KEEP "KARBATE" PIPE ALWAYS IN STOCK!

- Resists the action of acids, alkalies and other chemicals
- Light weight with adequate strength
- Resistant to mechanical shock
- Immune to thermal shock
- Easy to machine and install
- Full range of sizes and fittings

Write for Installation Manual M-8801-A.
Address Dept. PR.

The term "Karbate" is a registered trade-mark of
NATIONAL CARBON COMPANY, INC.
Unit of Union Carbide and Carbon Corporation
UCC
30 East 42nd Street, New York 17, N. Y.
Division Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco
Foreign Department: New York, U. S. A.

3. "Karbate" pipe being joined to gas inlet of a "Karbate" absorption tower by means of strong "Type V" flanged connection. Note flat place on bolt in foreground. This provides purchase for the second wrench to assure tightness in joint.

THESE PRODUCTS SOLD IN CANADA BY CANADIAN NATIONAL CARBON CO., LTD., TORONTO 4, CANADA

DURALOY

Where the Oil Industry Gets Its GOOD Tube Supports

For years, we have been supplying tube supports to many refineries . . . alloyed to meet each refinery's corrosion and heat-resisting requirements . . . melted and cast by experienced high-alloy foundrymen.

To serve you — if you, too, would prefer to have Duraloy cast tube supports —we offer the most modern and best equipped exclusively high alloy foundry in the field.

THE DURALOY COMPANY

Office and Plant: Scottdale, Pa. • Eastern Office: 13 East 41st Street, New York 17, N. Y.

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1743 McCormick Building
Chicago, Illinois

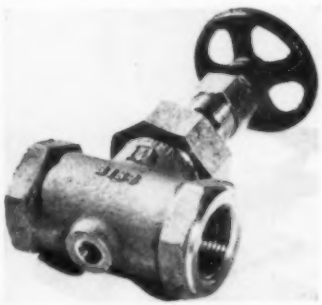
Detroit:
F. B. CORNELL & ASSOCIATES

METAL GOODS CORP.: St. Louis • Houston • Dallas • Tulsa • New Orleans • Kansas City

permit removal of the disc carrier pin from either side.

For a copy write The Lunkenheimer Company, Cincinnati, Ohio, referring to PETROLEUM REFINER item 265.

Mixer Valve (Item 266)



Ansul Chemical Company has developed an all-stainless steel valve for mixing liquid or gaseous sulfur dioxide and water. Water inlet and outlet are standard one inch pipe thread. The sulfur dioxide inlet is ¼ inch pipe thread. The valve is claimed to be suitable for any application where a continuous supply of a SO_2-water mixture is desired. The valve control handle regulates the flow of sulfur dioxide into the valve. With the proper auxiliary equipment, "specific concentrations are maintained."

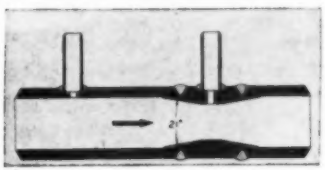
For further information write Ansul Chemical Company, Marinette, Wis., referring to PETROLEUM REFINER item 266.

Alloy Steel Studs, Etc. (Item 267)

A new 48-page Catalog Handbook on heat treated alloy steel studs, bolts and nuts is available from Texas Bolt & Supply Company. Including metallurgical data, specifications and prices the booklet presents detailed information on the complete line of fastening and anchoring materials manufactured by and carried in stock by the company.

For a copy of the booklet write Texas Bolt and Supply Company, 2020 Commerce Street, Houston, referring to PETROLEUM REFINER item 267.

Venturi Tubes (Item 268)

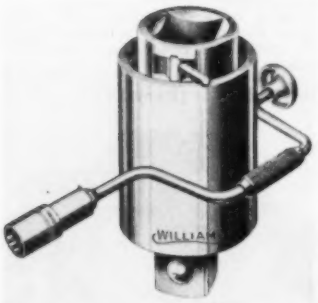


Republic Flow Meters Company has fabricated Venturi tube assemblies for line sizes of ¾ to 3 inches. Supplied with welding ends and stub end welding nipples for measurement connections, these are recommended where line fluid velocities are so high that excessive differential range is required with an orifice plate, where solids in suspension in the line fluid tend to deposit in the space imme-

diately ahead of or after an orifice, or on the orifice plate itself.

For further information write Republic Flow Meters Company, 2240 Diversey Parkway, Chicago 47, referring to PETROLEUM REFINER item 268.

Ratchet Adapter (Item 269)



Use of the new ratchet adapter of J. H. Williams & Company with any of the company's ½ inch square drive handles or attachments converts it to a ratchet tool. Length of the tool is 2 9/16 inches and diameter is 1¼ inches. The ratchet-gear has 30 teeth and "shift lever reverses action instantly."

For a copy of Booklet A-50 write J. H. Williams & Company, 400 Vulcan Street, Buffalo 7, N. Y. referring to PETROLUEM REFINER item 269.

High-Pressure Gauge (Item 270)

In the high-pressure gas and liquid gauge developed by United States Gauge, a solid wall, cast integral with the case, separates the Bourdon tube and movement section from the observer. The entire back of the case is fitted with a spring mounted safety release. The Bourdon tubes are threaded at both ends for interference fit. The springs are attached to the threaded socket and tip and sealed against a specially designed cone. Accuracy is "one percent of full scale reading on all pressures up to 50,000 pounds and two percent of reading on all pressure above that."

For further information write United States Gauge, Division of American Machine and Metals, Inc., Sellersville, Pa., referring to PETROLEUM REFINER item 270.

Welding Fittings (Item 271)

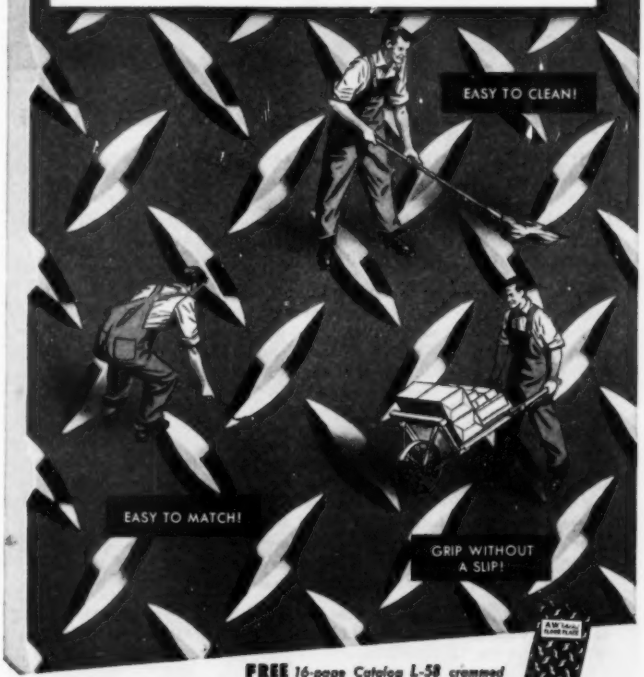
Taylor Forge & Pipe Works are producing a new line of welding fittings. The compound Tanj-Ells for gas transmission pipelines is designed with 6-inch tangents on each end, but spanning two angles connected with a double 12-inch tangent. The fitting containing two angles is in one piece without intermediate buttwelds. Tanj-ells are made

No More Slipping Accidents!

AW SUPER-DIAMOND FLOOR PLATE

A Better Footing for Product and Plant

Put this floor plate in your plant—or on your product—and say goodbye to costly slipping accidents. Even when the surface is wet or oily, exclusive engineered design with Super-Diamonds at 45° angles gives grip-without-a-slip safety! Easy to match without waste. Easy to clean with mop, broom or hose. Needs no maintenance. Use AW Super-Diamond for safe, strong, clean walkways, loading platforms, fire escapes, trench covers, running boards, machine tool bases—1001 other product and plant applications.

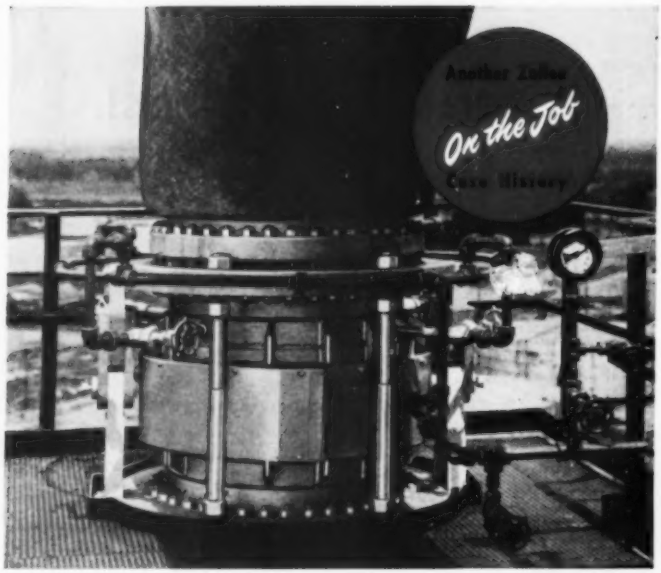


FREE *16-page Catalog L-58 crammed with valuable information. Write now.*

AW SUPER-DIAMOND
FLOOR PLATES THAT GRIP

A Product of **ALAN WOOD STEEL COMPANY**
Conshohocken, Pa.

Other Products: Permaclad, Stainless Clad Steel • AW Super Grip, Abrasive Floor Plate • Billets • Plates • Sheets (alloy and special grades)



Expansion Joints Without Anchors

PICTURED ABOVE is one of two 34" diameter Zallea Stainless Steel *Hinged* Expansion Joints, among several installed in the U. O. P. designed cat cracker at a large Mid-western refinery. Located more than 150 feet above the ground these two 34" Zallea joints absorb 8½" movement of the piping between the reactor and stripper, operating at 1150° F.

Whereas most types of expansion joints use guides and anchors and usually compensate for axial movement only—2 or 3 of these Zallea Stainless Steel *Hinged* Expansion Joints, spaced a given distance apart absorb all the axial and lateral movement of any system of piping in one plane. Self-supporting at all times, each joint bends angularly giving the same effect as a hinge at each elbow. This action reduces bending stresses in the piping and eliminates cumbersome anchors and supports.

In similar jobs in other refineries . . . wherever there is a need for simplified piping . . . Zallea Stainless Steel *Hinged* Expansion Joints are used, many in service since 1940. Each Zallea Stainless Steel *Hinged* Expansion Joint is designed for a specific job—designed after a thorough study of the piping problems involved. On special order, they are available in sizes up to 72" diameter and 1000 pounds pressure, as well as for temperatures up to 1600° F.

For information on the complete line of Zallea Expansion Joints—send today for Catalog 47. ZALLEA BROTHERS, 890 Locust Street, Wilmington 99, Delaware.

Zallea
EXPANSION JOINTS

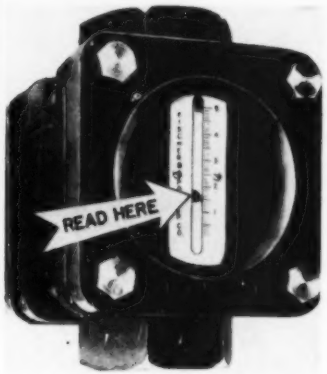
WORLD'S LARGEST MANUFACTURERS OF EXPANSION JOINTS EXCLUSIVELY

New Equipment

in four units: 2½ to 5 degrees, 1½ to 10 degrees, 14 to 26 degrees and 45 to 90 degrees. It is claimed that every grade of gas transmission line pipe, whether welded or seamless, can be matched in fittings, including Weld-ells, Tanj-ells, tees, river crossing headers, welding heads, reducers, etc. Sizes range from 8 to 36 inches.

For a copy of Bulletin 492 write Taylor Forge & Pipe Works, P. O. Box 485, Chicago 90, referring to PETROLEUM REFINER item 271.

Flow Indicator (Item 272)



Fischer & Porter Company's new flow indicator feature "through-bolted construction, high pressure ratings, close fit into a vertical section of pipe and just one moving part in the fluid stream." Made in sizes from ¾ to 4 inches for either screwed or flanged construction, the indicator measures maximum flow rates of 3.5 to 250 gpm. A fixed diameter orifice is located at the vertical inlet of the standard Bull's Eye body. A tapered plug with a permanent magnet is suspended in the fluid stream within the orifice, causing an external steel ball to move against a calibrated flow scale when the plug rises against the flow rate. Observation of the fluid is possible through a Herculite glass window.

For further information write Fischer & Porter Company, Hatboro, Pa., referring to PETROLEUM REFINER item 272.

Stainless Castings (Item 273)

The Cooper Alloy Foundry Company has started publication of "Newscast," a new periodical for those who design, specify, use or purchase stainless steel valves, fittings and engineered castings. It provides information about the uses and properties of stainless steel castings.

For a copy write The Cooper Alloy Foundry Company, Bloy Street and Ramsey Avenue, Hillside, N. Y., referring to PETROLEUM REFINER item 273.

Temperature Ratings (Item 274)

Additional high temperature ratings of Tempilstiks® and Tempil® pellets have been developed by Tempil® Corporation. Both these temperature-indicating products can be obtained now in the

range between 1600° and 2000° F. Beginning with 113° F., Tempilstiks° and Tempil° pellets are now available in 12½° steps to 400° F. and in 50° steps from 400° to 2000° F.

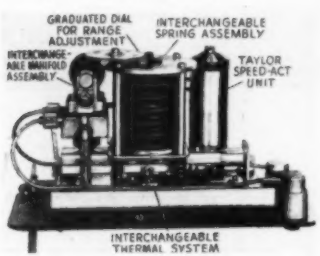
For further information write Tempil° Corporation, 132 West 22nd Street, New York 11, referring to PETROLEUM REFINER item 274.

Tank Heaters (Item 275)

Typical installation arrangements and a cut-away section showing the dimensions of type TF-20 tank heaters is presented in Bulletin 491 issued by The Brown Fintube Company. Vertical mounting of the tubes "eliminates depositing of materials on the tube" and a thermal siphon or "flow" set up within the tank "avoids stratification." The heaters are easily removed and repaired or cleaned outside the tank, it is claimed.

For a copy of the bulletin write The Brown Fintube Company, Elyria, Ohio, referring to PETROLEUM REFINER item 275.

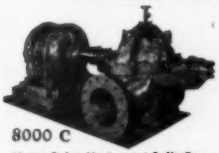
Transmitter (Item 276)



Designed for those applications where it is desirable to have the indication, record or control remotely located from the point of measurement, the new force-balance type pneumatic temperature transmitter developed by Taylor Instrument Companies incorporates Speed-Act which applies the principles of Pre-Act or derivative action directly to temperature determination. Its output in psi. "is proportional to the temperature of its

PUMPS

BUILDERS OF OUTSTANDING PUMPS SINCE 1869



8000 C

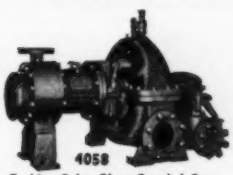
Motor Drive Horizontal Split Case Double Suction Centrifugal Pump

8001

Turbine Drive Horizontal Split Case Multi Stage Centrifugal Pump

4049 A

Two Stage Close Coupled Centrifugal Pump



4058

Turbine Drive Close Coupled Centrifugal Pump

942

Single Style, Packed Piston Pattern Steam Pump

2352 B

Durable Duplex, Outside End Packed, Plunger Pattern Steam Pump

3918

Durable Duplex, Packed Piston Pattern Steam Pump

3833

Horizontal Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump

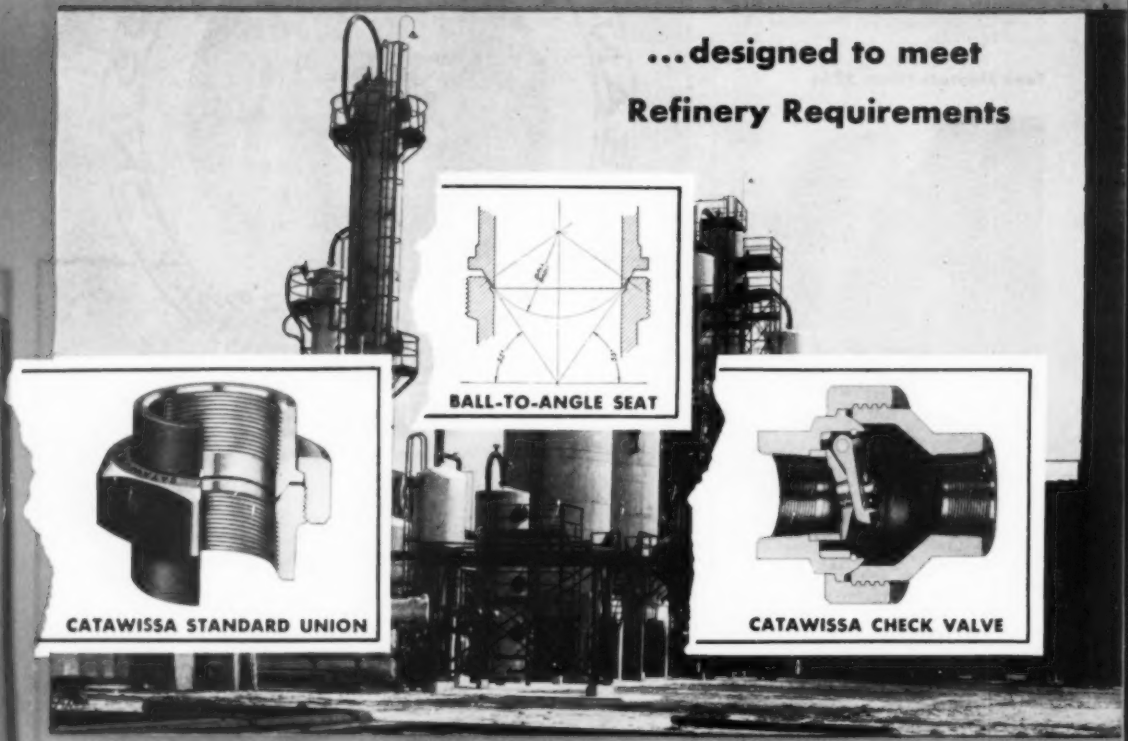
ESTABLISHED 1869

DEAN BROTHERS PUMPS INC.

INDIANAPOLIS IND.

323 W. TENTH ST.

Always specify "CATAWISSA" Unions and Check Valves



"OILWELL'S" strategically located refinery stock points carry complete lines of Catawissa forged-steel unions and check valves that meet the most severe refinery specifications.

CHECK THESE FEATURES

HOT-FORGED . . . from solid, rectangular steel bars, Catawissa Unions are free from sand and blow holes. They will expand and contract with the pipe, assuring tight joints.

THREADS—Catawissa Unions and Valves are supplied with either full ACME threads or U. S. Standard V-threads in the union nuts and on the female end.

SEATS . . . in all Catawissa Unions are a 55° angle on the female end to a BALL on the male end, assuring a perfect seal even when the pipe is not perfectly aligned. Carefully hand-ground seats which require no packing are inspected and tested under water to assure holding qualities.

Contact your nearest "Oilwell" representative—to assist you with your refinery problems.

OIL WELL SUPPLY COMPANY

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Export Division Office—
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HOUSTON, TEXAS . . . TULSA, OKLAHOMA
LOS ANGELES, CALIFORNIA

USS "OILWELL"

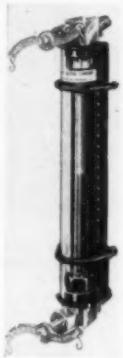
UNITED STATES STEEL

thermal element." Also claimed are rapid speed of response, short range spans, adjustable operating ranges, fixed air output range of 3 to 15 psi. for full tempreature span, compensation for barametric and ambient temperature changes, interchangeable unit assemblies and thermal systems built to withstand overrange temperatures up to 1000° F.

For a copy of Bulletin 98140 write Taylor Instrument Companies, Rochester 1, N. Y., referring to PETROLEUM REFINER item 276.

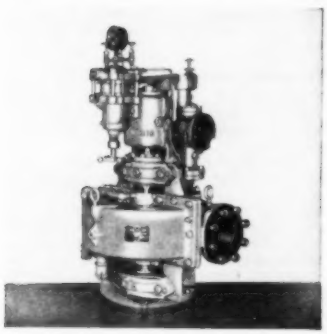
Gauge Glass Guard (Item 277)

Approved by the California State Department of Labor, this gauge glass guard of Wright-Austin Company is known as No. 28 Kleervu. Top and bottom cadimium plated supports for the protector have been redesigned to provide a lip which fits inside the Nuglas front, completely enclosing the gauge glass and "preventing the escape of injurious fluids such as hot chemicals, propane gas, live steam or hot liquids." It will fit any gauge upon which the dimension of the packing nut does not exceed 1⅞ inches across the hexagon. This guard can be furnished in sizes ranging from 4 to 8 inches in height. Nuglas, the material forming the front part of the guard is claimed to be unaffected by the force of an exploding gauge glass or by escaping steam or hot water.



For further information write Wright-Austin Company, 315 West Woodbridge Street, Detroit 26, Mich., referring to PETROLEUM REFINER item 277.

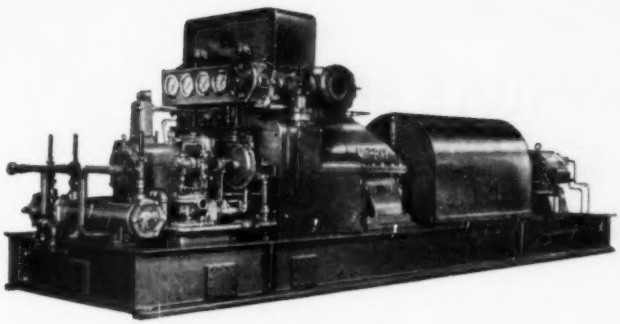
Vertical Steam Turbine (Item 278)



Whiton Machine Company has developed a small vertical steam turbine which is "capable of developing horsepower ratings up to 90 brake horsepower." Available in either semi-steel or cast steel, it is claimed to meet the requirements of practically any steam

MURRAY

TYPE D TURBO-GENERATOR



Murray Type D turbo-generators are built in a capacity range from 500-3000 KW. Turbines are either direct-connected to 2-pole generators or operate through reduction gears connected to 6-pole generators at 1200 RPM. Direct current and 25 cycle machines are also available. This type machine is regularly furnished in the above capacity range either condensing or non-condensing and may be of the automatic extraction type or for high back pressure. Units may be mounted either on soleplates or on a fabricated steel base.

This type turbo-generator is designed to operate on steam conditions up to 600#, 750° F. TT. Auxiliary equipment normally includes combined trip throttle valve, complete pressure lubrication system including oil tank, oil filter, coolers, and automatic turbine-driven auxiliary oil pump. Gauge board with gauges, vibrating reed tachometer and necessary thermometers are also furnished.

The above photograph shows a machine of this type rated at 1000 KW. Two duplicate machines are installed in our Nation's Capitol.

Murray turbo-generators have long been noted for their rugged construction, operating economy and long life with a minimum of maintenance.

WRITE TODAY FOR FULL DETAILS

MURRAY IRON WORKS COMPANY

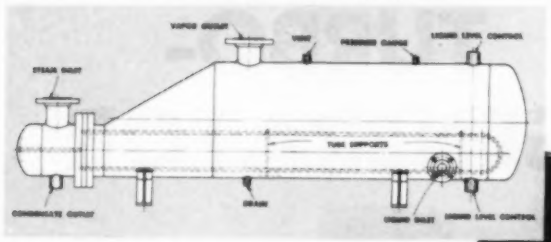
BURLINGTON, IOWA

BUILDERS OF STEAM POWER EQUIPMENT FOR THREE QUARTERS OF A CENTURY

B.T.U. *digest*

THROWING LIGHT ON HEAT TRANSFER PROBLEMS

THE WHITLOCK MANUFACTURING COMPANY
149 BROADWAY, NEW YORK 6, NEW YORK
Main Office and Plant, 75 South St., Elmwood, Hartford 2, Conn.
NEW YORK • CHICAGO • BOSTON • PHILADELPHIA • DETROIT • RICHMOND
In Canada: DARLING BROS., LTD., Montreal



WHITLOCK REBOILERS *NOW STANDARDIZED!*

THERMAL DESIGN

The Whitlock Type KR Kettle Type Reboiler has now been designed to meet the need of industry for a standard, low-cost vaporizer adapted to multi-purpose process requirements. Using propane as an example, standard sizes provide vaporizing rates ranging from approximately 1,000 to 12,000 lbs. per hour. The Type KR Reboiler is of all-steel construction and is ideal for any service where conditions are non-corrosive to steel. The overall design results in standard reboilers answering the requirements of a wide range of individual operating conditions. Maximum heat flux, boiling rates, fluid velocities, vapor disengagements—these and other factors are considered as they relate to a given installation, and represent the background for each Whitlock recommendation.

MECHANICAL AND PHYSICAL DESIGN

The Type KR Reboiler is of a U-tube design which has proved so satisfactory for steam-tube service. With the eccentric conical port head, the tube bundle is placed low in the shell, thus minimizing the shell size.

While we have discussed only the standard all-steel construction, corrosion-resistant materials may be utilized where process fluids make it advisable. Whitlock Bulletin No. 130, issued recently, gives a detailed description of these standardized reboilers. Why not send for your free copy?

SIZE NO.	APPROX. VAPOR RATE LBS. HR.*	OVERALL LENGTH	SHELL DIAMETER	CHANNEL DIAMETER	VAPOR OUTLET	LIQUID INLET	STEAM INLET	CONDENSATE OUTLET
1	915	7' 0"	18"	6"	2"	1"	2"	½"
2	1,830	7' 4"	18"	8"	3"	1¼"	2½"	½"
3	3,050	7' 3"	24"	10"	4"	1½"	3"	¾"
4	6,100	12' 6"	24"	10"	4"	2"	4"	1"
5	9,150	13' 0"	30"	12"	5"	3"	4"	1¼"
6	12,200	13' 6"	30"	14"	6"	3"	5"	1½"

* Approximate vapor rates based on heating propane from — 12° F. to 100° F. and vaporizing, when supplied with sufficient steam at 5 p.s.i.g.

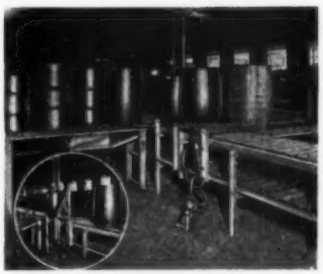
WHITLOCK

DESIGNS and BUILDS Bonds • Coils • Condensers • Coolers • Heat Exchangers
Heaters • Piping • Pressure Vessels • Receivers • Reboilers

pressures and temperatures. The standard machine "can take thrust loads in either direction up to 1500 pounds and can be changed to take even higher thrust loads." Equipped with both constant speed and emergency governors, the turbine also has a bolting flange at the lower part of the casing to permit bolting to the flange of the driven unit.

For further information write Whiton Machine Company, New London, Conn., referring to PETROLEUM REFINER item 278.

Drum Handling System (Item 279)



The Alvey-Ferguson Company has developed a coordinated system combining apron conveyors, gravity roller and live roller conveyors and a system of automatic, air-actuated deflectors to solve drum and barrel handling problems. An automatic brake and an end-stop control the release of the drums from the gravity roller conveyor onto the main apron conveyor line. Drum movement along the main conveyor is controlled by the deflectors which direct selected drums off the apron conveyor and onto the proper gravity roller spur to storage. In the photograph, drums are temporarily halted on the filling line at the left while drums from another filling line are being deflected onto the proper spur to storage. Inset shows one of the deflectors raised so drums move on the main apron conveyor to other storage points.

For further information write The Alvey-Ferguson Company, Cincinnati, Ohio, referring to PETROLEUM REFINER item 279.

Viscosity Abacus (Item 280)

Belgian oil technologist, Michel Roegiers offers an abacus for determining the viscosities of mixtures of petroleum oils.

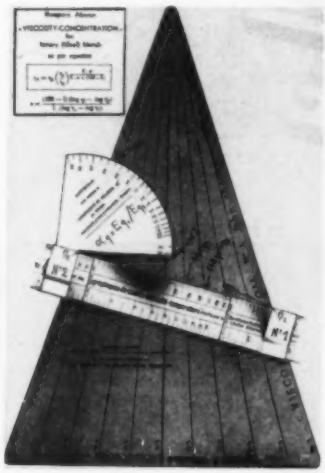
According to Roegiers, "within the limits of ideal mixtures, the logarithms of viscosity are additive when the blending proportions of the component liquids are expressed in unit-fractions of intermolecular attraction energy." The practical equation of this academic law, for binary systems (which includes the refined Newtonian petroleum oils) may be written:

$$\eta_x = \eta_2 \left(\frac{\eta_1}{\eta_2}\right)^{\frac{X.\alpha}{X.\alpha + (100 - X)}}$$

η_x = viscosity (in absolute units) at temperature T of a binary ideal mixture containing X% (either weight, volume or mole) of liquid No. 1 of vis-

cosity η_1 and (100 — X)% of liquid No. 2 of viscosity η_2.

α = a constant (energy-blending factor) proper to each binary ideal system at temperature



T. It expresses the ratio $(E/q)_1/(E/q)_2$,—i.e. the ratio of the specific intermolecular attraction energies, E ergs per unit of quantity q, of the component liquids No. 1 and No. 2 at temperature T. q must of course relate to *that* unit of quantity — weight, volume or mole—as referred to by X.

The numerical value of α may be deduced from the viscosity $\eta\xi$ of an experimental mixture containing ξ% of liquid No. 1 + (100 — ξ)% of liquid No. 2 by following equation:

$$\alpha = \frac{(100 - \xi)(\log \eta\xi - \log \eta_2)}{\xi\ (\log \eta_1 - \log \eta\xi)}$$

The author has conceived an abacus which "solves mechanically and simultaneously both above equations rapidly and with slide-rule accuracy."

For further information write Michel Roegiers, Elektrion Oil Laboratories, Coupure 221, Ghent, Belgium, referring to PETROLEUM REFINER item 280.

Pipe Tools (Item 281)

Toledo Pipe Threading Machine Company's new catalogue describes the complete line of Toledo pipe tools, power pipe machines, power drives and accessory equipment.

For a copy of the catalog write Toledo Pipe Threading Machine Company, Toledo, Ohio, referring to PETROLEUM REFINER item 281.

Relief Valves (Item 282)

Information on dimensions and weights, design detail and corect installation is included in Edward Valves, Inc.'s Bulletin 711. The relief valves are designed for a basic steam, oil or vapor

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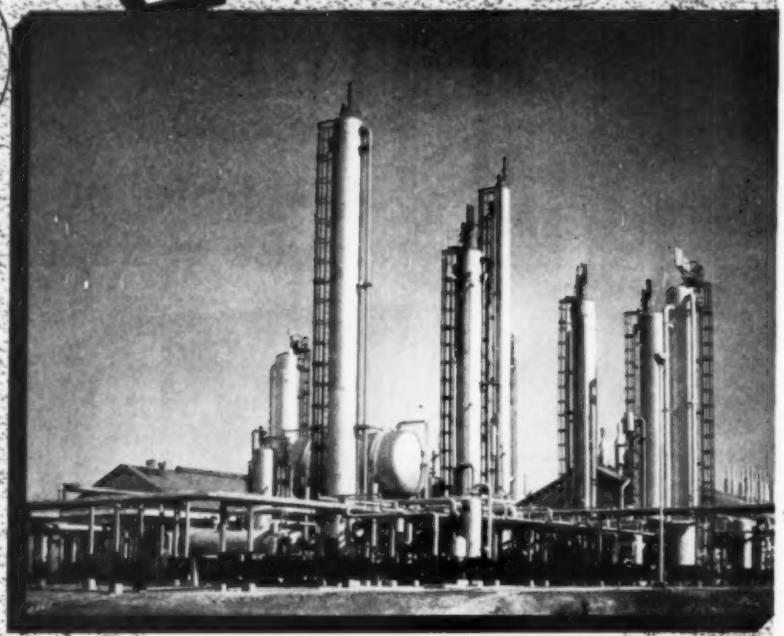

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working pressure of 600 pounds at 850° F., but can be furnished with special carbon springs.

For a copy write Edward Valves, Inc., East Chicago, Ind., referring to PETROLEUM REFINER item 282.

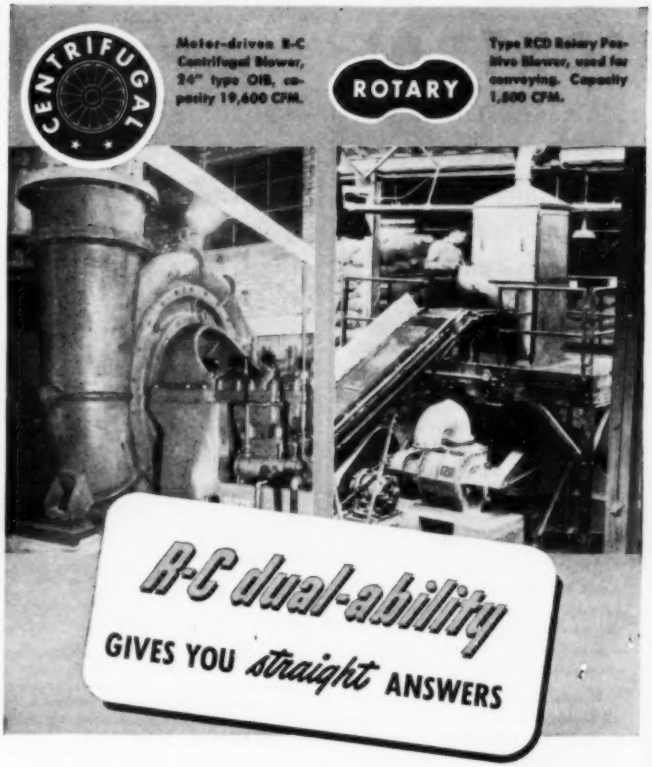
Indicating Controller (Item 283)

Wheelco Instruments Company has introduced a new indicating controller to its Capacitrol line for the measurement and control of process variables. Features include front accessibility, plug-in chasis design, voltage selector plug and a distant view scale. The Multi-Switch Capacitrol has a maximum of four switches (S. P. D. T.). The Wheelco electronic principle is used to link the measuring and control functions.

For further information write Wheelco Instruments Company, 847 West Harrison Street, Chicago 7, referring to PETROLEUM REFINER item 283.

Seatless Piston Valves (Item 284)

In the new Strahman valve, manufactured by Klingerit, Inc., a stainless steel piston sliding into the ring "effects positive closure because of long sealing surface." The ring is also available in materials suitable for hard-to-hold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liquids or gases. Easily replaceable, the ring may be further compressed against the piston by a take-up on the bonnet while the valve is in service. The valve is suitable for a low or high temperature range of minus 125° to plus 750° F.

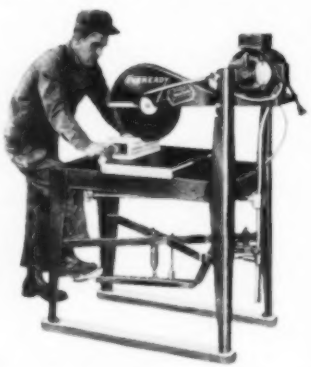
For further information write Klingerit, Inc., 20 Hudson Street, New York 13, referring to PETROLEUM REFINER item 284.

Inner Valve (Item 285)

Used exclusively in its "500" series of regulating valves, the new cup disc and piston seat design inner valve, manufactured by Klipfel Manufacturing Company, is balanced when open and controlled by the diaphragm. Changes of inlet pressure "are unaffected when it is open but when closed, it is held tight against the single seat." As used in back pressure valves the inlet pressure under the seat "enters the cup and lifts it against the resistance of a spring adjusted for a definite pressure." The series is designed for control at inlet pressure below 250 pounds and reduced pressures below 150 pounds. Sizes range from ¾ to 6 inches.

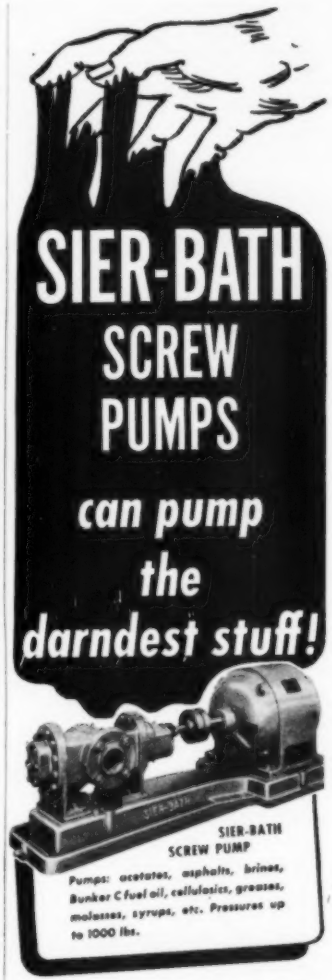
For further information write Klipfel Manufacturing Company, Hamilton, Ohio, referring to PETROLEUM REFINER item 285.

Masonry Saw (Item 286)



Eveready Briksaw Company's new masonry saw features "both wet and dry cutting and instant portability" and a cutting head "which can be removed from the saw without using tools, is adjustable for different size materials and can easily be reset." An automatic blade spring adjusts the blade pressure to the hardness or softness of the material. A complete line of blades is available in dry abrasive, wet abrasive and diamond blades.

For a copy of Folder PR 49 write



No matter how gooey the stuff, it can't "gum up the works" in a Sier-Bath Screw Pump. The powerful thrust of its screw moves materials so viscous that they are often in a semi-solid condition.

The simple design (only two moving parts) and accurate but sturdy construction, make these screw pumps long-lived and keep them relatively free of maintenance. They are available in horizontal and vertical models. Send for booklet.

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New Equipment

Eveready Briksaw Company, 1509 Michigan Avenue, Chicago 5, referring to PETROLEUM REFINER item 286.

Chain Wheel Valve (Item 287)

The newest addition to Pacific Valves, Inc.'s line of cast steel valves is a permanent type chain wheel valve which "replaces the handwheel of the valve." Primarily for Pacific valves, it is recommended for use where a permanent installation is required. The universal type wheel can be attached to the rim of the valve's handwheel and is recommended for use where a quick or temporary installation is needed. The company also has expanded its line of cast steel gate valves to include the 900 pound series.

For further information write Pacific Valves, Inc., 3201 Walnut Avenue, Long Beach 7, Calif., referring to PETROLEUM REFINER item 287.

Blueprint Cabinet (Item 288)

Filing blueprints safely and conveniently without wrinkles, creases or curled edges, Empire Development Corporation's Draw-in-Dex blueprint cabinet accommodates 1000 prints. Any print can be removed without disturbing the

No wonder the man's "satisfied"

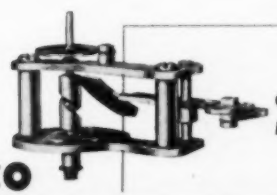
A user* of HELICOID gages wrote: "This gage gave us three and one-half years service on a Centrifugal boiler feed pump, where conventional gages had been wearing out the gears in four to six months. Needless to say we have been satisfied."

This is typical of the experiences of Helicoid gage users. They have found out how to save money.

Using a price of $20.00 for a 6" steel tube gage (and there's no premium in price for Helicoid), the cost for conventional gages would be $40.00 to $60.00 per gage, per year, in contrast to the cost of $5.71 per gage, per year, for Helicoid.

Thus, the money made by using Helicoid would be from $34.29 to $54.29 per gage per year. Send for your copy of the new Helicoid Gage catalog now.

**Name on request*



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Okadee Valves for butane and propane service are available in all popular sizes, with single or double seats, screwed or flanged connections, for lever, rack and pinion or gear operation.

FOR LOADING RACKS

Okadee Loading Rack Valves permit faster, safer loading and provide complete protection against line surge. Pressure - balanced discs permit the valves to be opened easily against all pressures and to close positively without shock. Closing speed is easily regulated through a simple adjusting screw. For additional safety, the operating lever is equipped for manual closing.

Okadee Loading Rack Valves are *full-opening*, providing port area equal to or greater than the pipe size for which they are designed. They are available in bronze or aluminum, in 2½", 3" and 4" sizes. Special trims can be furnished on order.

YOUR WECO REPRESENTATIVE will be happy to furnish full details on OKADEE Valves, which are available in a variety of types, trims and sizes for many services.

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others. An index file locates the prints instantly. Suspension rods support the drawings that are attached to manila hangers. They are designed so that when the front panel is opened, any drawing may be filed or removed. The cabinet is 4 feet high, 2½ feet wide and 20 inches deep. Index cards and lock are standard equipment.

For further information write Empire Development Corporation, 52 Broadway, New York 4, referring to PETROLEUM REFINER item 288.

Rotameters (Item 289)

The new multi-tube rotameter, offered by Brooks Rotameter Company, can be built with two or more rotameter tubes for use on related flows. The rotameter end fittings are fastened to a metal back plate with dowel pins and cap screws and the front of the unit has a plastic window ¼ inch thick. Each tube with its fittings "may be removed without disturbing any of the other parts."

For further information write Brooks Rotameter Company, Lansdale, Pa., referring to PETROLEUM REFINER item 289.

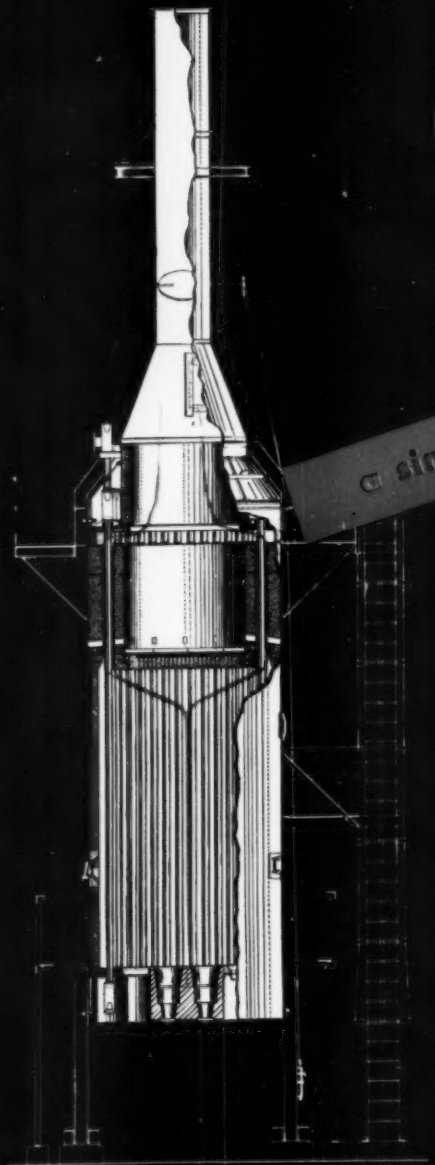
Water Flow (Item 290)

Measuring the flow of water from an open pipe is explained in a new booklet issued by Layne & Bowler, Inc., which discusses the Layne pipe orifice meter method. Flow graphs for various pipe sizes, as well as original calibrations conducted in the hydraulic laboratories of Purdue University are included.

For a copy write Layne & Bowler, Inc., P. O. Box 215, Hollywood Station, Memphis 8, Tenn., referring to PETROLEUM REFINER item 290.

Training Course (Item 291)

In the 40th anniversary issue of Oakite News Service, publication of Oakite Products, Inc., the training course for field service specialists is featured. Two trainees are followed through the company's chemical research and service laboratories, into special lecture sessions by its field engineers and through the other phases of the course, learning the latest technical



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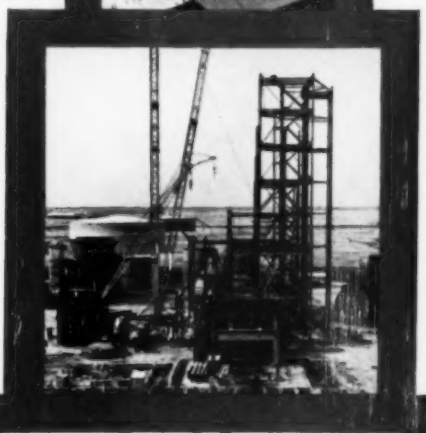

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developments and techniques of industrial cleaning and related operations.

For a copy write Oakite Products, Inc., 22 Thames Street, New York 6, referring to PETROLEUM REFINER *item* 291.

Barrel Stand (Item 292)

With the barrel stand, developed by Modern Equipment Company, one man can lift and put a heavy barrel in position to be drained into cans and buckets. All parts of the frame are of structural steel, electrically welded, handles are adjustable and wheels may be either rubber tires or metal. Operation of the barrel stand is described in a company bulletin.

For a copy write Modern Equipment Company, 2007-11 Cuming Street, Omaha 2, Neb., referring to PETROLEUM REFINER *item* 292.

Compressors (Item 293)

With electric, steam or gas turbine drive, the new axial flow compressors of Clark Brothers Company, Inc. have adiabatic temperature rise efficiencies up to 85 percent. Suction volume ranges from 20,000 to 300,000 cubic feet per minute. Construction and operation features as well as flow compressor performance and a cross section of a typical compressor are included in a new company bulletin.

Designed specifically for high pressure and large temperature differential duty, the multi-stage centrifugal compressors of Clark feature sealing and isolation of bearing chambers, water cooling,

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check valves and counter-balancing. Standard dimensions of the compressors, construction details and cross sections of a typical compressor are included in a second bulletin.

For a copy of the bulletins write Clark Brothers Company, Inc., Olean, N. Y., referring to PETROLEUM REFINER *item* 293.

Pressure Data Table (Item 294)

Maximum allowable working pressures for water-tube and fire-tube boilers have been assembled in a table by The Babcock & Wilcox Tube Company. The table lists the maximum allowable working pressures in pounds per square inch for seamless and electric-resistance welded carbon steel tubes or nipples for different diameters and gages of tubes conforming to certain A. S. M. E. specifications.

For a copy of Data Card 113 write The Babcock & Wilcox Tube Company, Beaver Falls, Pa., referring to PETROLEUM REFINER *item* 294.

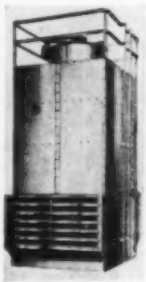
Combination Pumps (Item 295)

Goulds Pumps, Inc.'s Bulletin 630-A1 describes the company's new "Industri-Jet" pump, a combination of the centrifugal pump with the jet or ejector in one compact unit. Available in sizes from ¾ hp. to 5 hp., the pump has a capacity up to 35 gpm., and will discharge at pressures up to 190 pounds, depending upon the capacity. It is suitable for handling cold water, hot water, kerosine, gasoline, alcohol, carbon tetrachloride and similar liquids. The pump has high suction lifts, automatically recovers lost prime and has no close clearances or air or vapor binding.

For a copy of the bulletin write Goulds Pumps, Inc., Senaca Falls, N. Y., referring to PETROLEUM REFINER *item* 295.

Cooling Tower (Item 296)

Verflow, the new medium capacity cooling tower manufactured by the Marley Company, Inc., is designed in wood or steel and has features previously found only in heavy duty industrial towers. Features include: "lifetime nail-less filling, balanced spray system with patented low pressure nozzles, access port to inspect and clean nozzles, totally enclosed motor, enclosed bearing housing with grease-packed bearings, airfoil section cast aluminum alloy fans, multiple-celled unit, corrosion-resistant paint on metal towers, double-sheathed wood casing on wood towers and hinged louver frames and removal louvers."



For a copy of Bulletin V-49 write The Marley Company, Inc., Kansas City, Kan., referring to PETROLEUM REFINER *item* 296.

Wax and Oil Solvent (Item 297)

Visco VS, a new high-flash-point solvent for wax, grease, lube oils, paint and fusible or soft resins has been announced by Visco Products Company, Inc. Claimed to be non-injurious to skin and non-corrosive, the solvent is recommended in removing oil-treating chemicals, wax, grease, lube oils, extreme pressure lubricants and paint from skin, wood or metal surfaces. It may also be used as a general solvent where a slight blue discoloration would not be objectionable.

For further information write Visco Products Company, Inc., City National Bank Building, Houston 2, referring to PETROLEUM REFINER *item* 297.

Corrosion-Resistant Alloys (Item 298)

Charts to help in selecting the right alloy for most corrosive conditions are featured in an American Brake Shoe Company bulletin. The comparative corrosion resistance of the most commonly used grades in different corrosive media is given. Listed are standard corrosion-resistant alloys showing ACI types, AISI types and Chemalloy grades with their nominal composition and mechanical properties.

For a copy write American Brake Shoe Company, 230 Park Avenue, New York 17, referring to PETROLEUM REFINER *item* 298.

Vibration Dampener (Item 299)

Shock Stops, manufactured by The Connecticut Hard Rubber Company, are a new type of rubber vibration dampener with a "semi-pneumatic" action available in 18-by-18 inch square sheets, which can be cut to the required size. Round shapes 3¼ and 2¼ inches in diameter are also available. The waffle-like grid of the Shock Stop design "tends to trap air with vibrations

Operate
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POSITIVELY
Give Long Service

70 Degrees . . . less than a quarter turn . . . opens an EVERLASTING valve to a full pipe-size, straight-line flow every time . . . or closes it with a drop-tight seal. In services where quick action is desired, this speed of operation is invaluable . . . and besides, the unique EVERLASTING design eliminates sticking, binding, wedging or clogging.

EVERLASTING Valves are self-grinding, self-compensating, and cannot be jammed. And, because sturdily built of tough, dependable materials, they give "everlasting" service. Made in straight lever and rack-and-pinion types, both screwed and flanged ends, for pressures up to 600 psi.

Write for Free Descriptive Bulletin

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SOME EVERLASTING VALVE SERVICES IN REFINERIES

Batch Treating Units
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How to Cut Costs on These Cleaning Jobs!

When you use Oakite materials and methods to speed cleaning and reduce equipment downtime on these jobs, you hold cleaning costs to a minimum.

- Cleaning Absorbers, Bubble Towers
- Cleaning Storage Tanks
- Stripping Paint from Drums
- Cleaning, Descaling Heat Exchangers

Your neighborhood Oakite Technical Service Representative will gladly give you helpful details. Contact him or write to Oakite Products, Inc., 50B Thames St., New York 6, N. Y., for cleaning data in Oakite's FREE "Petroleum Cleaning Digest."

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OAKITE 1909 1949 40th ANNIVERSARY YEAR

OAKITE
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SPECIALIZED INDUSTRIAL CLEANING

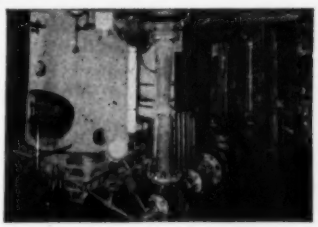
MATERIALS • METHODS • SERVICE

What's *behind* a CROLL C R REYNOLDS Evactor?

1

Instruments in the CR laboratory set up for measuring extremely high vacuum.

The production of Evactors is no routine operation at the Croll-Reynolds plant. Although CR engineers have over thirty years of industrial vacuum experience to guide them, the Croll-Reynolds testing and development department is one of the important units of the company. Development work is constantly under way to improve the efficiency of Croll-Reynolds Evactors wherever it is possible. It is this never-ending research and development which give CR Evactors their exceptional efficiency.



2

Special boiler in the CR pilot plant for providing unusual conditions of high pressure steam or superheat (or both) to duplicate the working conditions in customers' plants.

3

A 30-inch CR Booster Evactor on test in a CR shop.

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CROLL-REYNOLDS CO.

17 JOHN STREET, NEW YORK 7, N. Y.

CHILL VACTORS STEAM JET EVACTORS CONDENSING EQUIPMENT

PENNSALT
Anhydrous Ferric Chloride

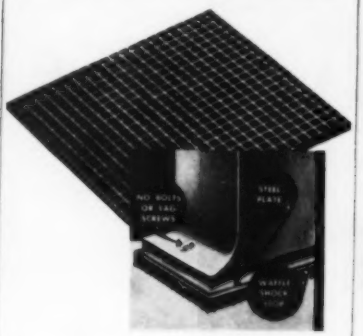
Catalyst in oil refining and organic reactions

Anhydrous Ferric Chloride is a water-free form containing 95.5%—98% $FeCl_3$ by weight. It is manufactured in this country exclusively by Pennsalt. Pennsalt Anhydrous Ferric Chloride possesses unique solubility in a wide range of organic solvents. This property makes it valuable as a catalyst in *condensation, polymerization* and *chlorination* reactions.

Properties:
Appearance—*fine, greenish-black crystals.*
Melting point—*Approx. 580° F.*
Boiling point—*Approx. 600° F.*
Bulk Density—*Approx. 85 pounds per cu. ft. as packaged.*
Solubility in water—*74.4 grams per 100 ml. at 32° F. 535.7 grams per 100 ml. at 212° F.*
Soluble in: *alcohol, acetone, ethers, pyridine, ethyl acetate, nitroethane, ethyl bromide and others.*
Other uses of Pennsalt Anhydrous Ferric Chloride: manufacture of iron salts, paint pigments, ceramics; condensing reagent in making intermediates; conditioning sewage sludge. For further information write:
Heavy Chemicals Division
Pennsylvania Salt Mfg. Company
Philadelphia 7, Pa.

PENN SALT
chemicals

New Equipment



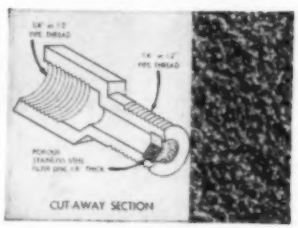
of unwanted amplitudes diverted by this air through the supporting ribs and do not pass to the supporting surface."

For further information write The Connecticut Hard Rubber Company, 407 East Street, New Haven 9, Conn., referring to PETROLEUM REFINER *item 299.*

Multi-Pointer Gages (Item 300)

Latest developments in Bailey multi-pointer gages are described in Bulletin 163-B being distributed by Bailey Meter Company. Use of the diaphragm operated unit for measurement of pressure, draft or differential is explained and some of the standard ranges available are listed. Four styles of casings, all

New and Exclusive!



Equipoise POROUS Stainless Steel PRESSURE SNUBBERS

These new snubbers utilize a porous stainless steel disk as the primary element to eliminate pulsations. They can be used to protect all types of pressure sensitive instruments. Namely, pressure gauges; pressure indicating and recording controllers; diaphragm type differential meters; U-tube manometers; differential flow meters; pump governors; and diaphragm regulators. They also can be used as filters or as flow meters on small flows.
The porous disk is made in several standard Grades. Special grades made to suit application.
Grade "G" Air, gases, Butane, gasoline.
Grade "E" Water, kerosene, light oils, etc.
Grade "D" Oil, etc., having viscosity over 300 SSU.
Write for literature — Dept. WL

EQUIPOISE CONTROLS
INCORPORATED
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2. Resistance to High Temperatures
3. Non-Magnetic
4. Non-Sparking
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8. High Strength
9. Long Life
10. Lower Ultimate Cost
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12. Easy to Plate or Finish
13. Resistance to Abrasion and Wear

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In Design, Construction and Materials

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It is a fine thing to propose wonderful theoretical ideas about well water systems and vertical turbine pumps, but Layne never ventures away from everyday basic ideas. That fact may account for the world-wide use and popularity of Layne Well Water producing equipment. It certainly accounts for such things as high efficiency, rugged construction and reliability of operation. So until the impossible happens, you can be sure that Layne engineers and designers are sticking to basic ideas that always pay off in satisfaction to the user.

Of course Layne Well Water Systems are as modern as tomorrow, in that they are properly designed and constructed of the finest tested and proved materials. Furthermore they are as accurate in precision building as modern tooling and experienced workmanship can make them.

In buying a well water system, you naturally want a full dollar's worth of value. You want a maximum amount of water at a minimum of daily operation cost—plus freedom from breakdown and repair expense. Those requirements just about sum up exactly what you get when you choose a Layne Well Water System. For further information, catalogs, bulletins, etc., address Layne & Bowler, Inc., Memphis 8, Tenn.

LAYNE

WELL WATER SYSTEMS

AFFILIATED COMPANIES: Layne-Arkansas Co., Stuttgart, Ark. • Layne-Atlantic Co., Norfolk, Va. • Layne-Central Co., Memphis, Tenn. • Layne-Northern Co., Mishawaka, Ind. • Layne-Louisiana Co., Lake Charles, La. • Louisiana Well Co., Monroe, La. • Layne-New York Co., New York City • Layne-Northwest Co., Milwaukee, Wis. • Layne-Ohio Co., Columbus, Ohio. • Layne-Pacific, Inc., Seattle, Washington • Layne-Texas Co., Houston, Texas • Layne-Western Co., Kansas City, Mo. • Layne-Minnesota Co., Minneapolis, Minn. • International Water Corporation, Pittsburgh, Pa. • International Water Supply, Ltd., London, Ontario • Layne-Hispano Americana, S. A., Mexico, D. F.

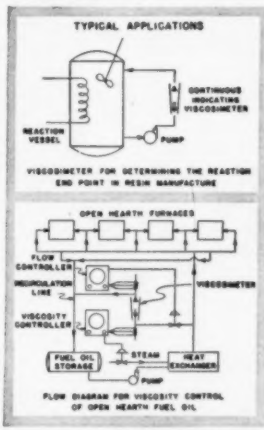
VISCOSITY MEASUREMENT

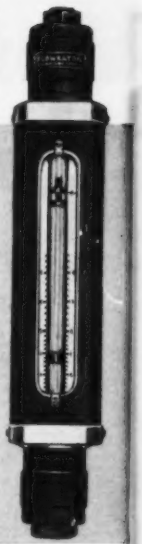
CONTINUOUSLY AUTOMATICALLY

(and with automatic control of the viscosity, if desired) RIGHT IN THE PIPE LINE, WITHOUT WITHDRAWAL OF FLUID SAMPLES, WITHOUT STOP-WATCH READINGS OF EFFLUX TIMES

NOW AN ACCOMPLISHED FACT

Viscosimeters have graduated from the class of laboratory test instruments to full-fledged industrial instruments which perform their function without manipulation by an operator, just as temperature, pressure, flow and level instruments have been doing for many years.





PRINCIPLE OF OPERATION

Continuous viscosimetry has been accomplished by utilizing one of the unique properties of the F & P FLOWRATOR meter (formerly rotameter); ability to make metering floats either viscosity sensitive or viscosity immune. Into one FLOWRATOR are placed two metering floats, the one so shaped that it is very viscosity sensitive, the other one with the patented F & P viscosity immune shape. When fluid flows upward through the tapered metering tube both floats will, of course, rise in the normal manner. However, the elevation of the one float will be relatively slight, since it is produced solely as a function of fluid flow rate. The other float elevation will be much greater since it is a function both of viscous drag and flow rate. The space increment thus created between the two floats is a direct measure of viscosity. By selecting any particular flow rate which will give a convenient elevation of the one float to serve as a reference line, the other float elevation may be marked as viscosity graduations in terms of centipoises, centistokes, S.S.U. or any other desired units. Viscosity measurement all the way from .0008 to 800,000 centipoises is now possible.

Write for catalog 88 giving much additional information. F&P VISCORATOR continuous viscosimeters have been thoroughly tested in trial installations for well over a year.

FISCHER & PORTER CO.

DEPT. 9R-1C HATBORO, PA.

FLOWRATOR

TRADEMARK

available in sizes to accommodate from 1-12 units, are also described. Data includes net and shipping weights plus complete dimensions of casings. Illustrations include photographs, diagrammatic drawings and cut-away drawings.

For a copy of the bulletin write Bailey Meter Company, 1050 Ivanhoe Road, Cleveland 10, Ohio, referring to PETROLEUM REFINER *item* 300.

Electronic Recorders (Item 301)

The acratron recorder of The Hays Corporation is an electronic type self-balancing ac. potentiometer for work in designing and developing special measuring or transmitting devices which require a recorder to give the desired indication and record. It is also being offered for resale to manufacturers of special measuring and transmitting devices to enable them to supply a complete recorder.

For a copy of Bulletin 49-909 and 48-829 write The Hays Corporation, Michigan City, Ind., referring to PETROLEUM REFINER *item* 301.

Industrial Cleaning (Item 302)

Speedylectric Jc-30 steam jet cleaner, manufactured by Livingstone Engineering Company, uses high pressure steam from its built-in boiler. The high-pressure steam is mixed with the proper amount of detergent at the jet, leaving

"no excess water to dilute the detergent or flood the working area." Boiler and jet have fingertip control and a pressure tank "assures positive flow of detergent." With "no coils or tubes to scale or burn out and no motors, pumps or moving parts to wear out," the equipment, operates on ac. current, 220 volts and over, single or polyphase, and is approved by the ASME and the Underwriters' Laboratories.

For further information write Livingstone Engineering Company, 100 Grove Street, Worcester 5, Mass., referring to PETROLEUM REFINER *item* 302.

Gate Valve (Item 303)

A new compact stainless steel union bonnet gave valve has been developed by The Cooper Alloy Foundry Company. This new corrosion resistant valve is the result of demands for "a small size stainless steel valve, simple in design." Construction features include ball and socket point contact discs which "adjust themselves in any position" and a minimum of six turns of packing "to insure effective sealing." The valve is supplied in ½, ¾ and 1-inch sizes. It is recommended for fixed plant installations as well as for use on fabricated equipment.

For further information write The Cooper Alloy Foundry Company, Bloy Street and Ramsey Avenue, Hillside, N. J., referring to PETROLEUM REFINER *item* 303.

Circulating Pumps (Item 304)

Byron Jackson Company's new line of single and multi-stage vertical circulating pumps are claimed suitable for heat-exchange applications where medium to high capacity are required as well as for dewatering, river intake and drainage pumps. The smaller sizes from 5-12 inches are available in capacities from 20 to 3000 gpm. Larger pumps are available in capacities of 1500 gpm. Suspended vertically, the pumps require little floor space. All parts are machined with shoulders and recesses forming metal to metal joints for rigid

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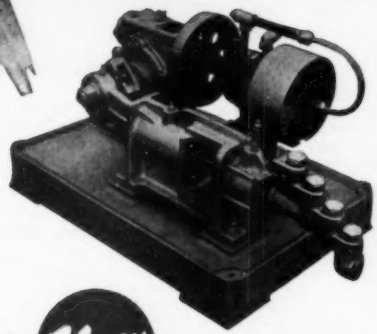
The "AIROMETRIC"



A New MILTON ROY CHEMICAL PUMP...

with Rotary Air (or Gas) Motor Drive

"Airometric" air powered pumps, like other Milton Roy Chemical Pumps, are positive metering units for controlled volume pumping, the volume of liquid pumped being quickly and easily regulated by varying the length of the plunger stroke. Precise control in pumping small volumes, down to one pint per hour, is thus made possible. Stroke adjustment and liquid end construction are the same as in standard Milton Roy electrically driven units. The power source is a rotary air (or gas) motor of approximately one horsepower. For applications requiring constant feed the pump speed is held constant by a governor which throttles the air exhaust. The speed of the motor may be regulated by any type of pneumatic controller thus regulating chemical feed as called for by the meter controller in any specific process. Example: Automatic pH control.

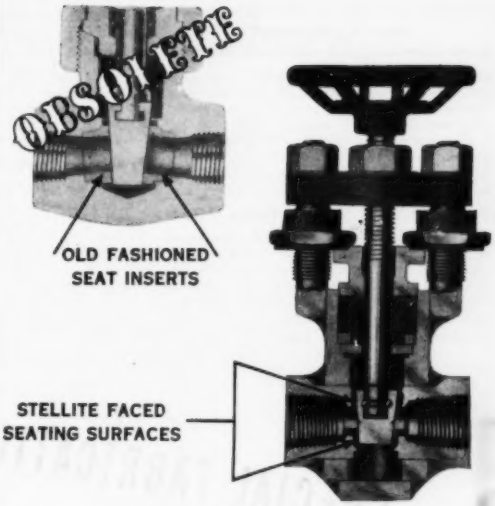
There are many uses for chemical pumps where electric current is not readily available but air or natural gas under pressure can be used as a source of power. In petroleum production, for example, pumps are needed for injecting chemicals into flowing oil wells to minimize corrosion, or for pumping treating chemicals into steam boilers or boiler feed water lines to prevent pitting, embrittlement and scaling. Also, in petrochemical processing operations where explosion hazards are present, the "Airometric" Pump makes positive metering possible at points of application without the danger of sparking which is inherent in electrical equipment.

The exclusive Milton Roy double-ball check valve and liquid end construction employed in "Airometric" Pumps are available in any iron, steel or alloy metal that can be cast and machined, also in certain plastic materials, to meet practically every corrosion resistant requirement.

For complete description, specifications, pressure and capacity tables, etc., write for Bulletin 488.

MILTON Roy COMPANY

1315 E. MERMAID LANE, CHESTNUT HILL, PHILA. 18, PA.



Hancock design "obsoletes" seat inserts

SUPER-HARD *Stellite* faced seating surfaces in Hancock GateValves are integral with the WELDVALVE body. They never need to be replaced, and leakage between body and seat is impossible.

The Hancock technique of accurately finishing before assembly, assures perfect alignment with the "500 Brinell" stainless steel wedge, and results in complete absence of distortion inherent in screwed-in and spun-in seat designs.

Excess handwheel pressure to align seating surfaces is not necessary for WELDVALVE tightness. *Perfect* alignment guarantees tight valves even on the upstream side of the wedge.

Designed for 800# at 750°F or 2000# at 100°F. Sizes ¼" to 2" inclusive.

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MAXWELL MANNING M&M MOORE INC. TRADE MARK

HANCOCK *Valves*

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Makers of Hancock Valves, Ashcroft Gauges, Consolidated Safety and Relief Valves and 'American' Industrial Instruments. Builders of 'Shaw-Box' Cranes, 'Budgit' and 'Load Lifter' Hoists and other lifting specialties.

alignment. The pumps feature lead-impregnated bronze bearings. The suction bell is grease-packed and all other bearings are water-lubricated.

For a copy of Bulletin 48-6050 write Byron Jackson Company, Terminal Annex, Box 2017, Los Angeles 54, referring to PETROLEUM REFINER *item* 304.

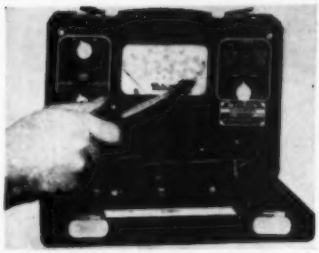
Pressure-Seal Valves (Item 305)

Details of design, material specifications, pressure-temperature ratings and charts for correlation of valve size and pressure drop are presented in Catalog Section 12-H, issued by Edward Valves, Inc. on its cast steel valve designs with pressure-seal bonnets for high pressure and high temperature service. The valves are built in both globe and angle stop, non-return and check designs in sizes from 6 to 14 inches for 900, 1500 and 2500 pound pressure classes.

For a copy of the catalog section write Edward Valves, Inc., East Chicago, Ind., referring to PETROLEUM REFINER *item* 305.

Precision Tachometers (Item 306)

The new precision tachometer of Metron Instrument Company has a total speed range for motor and generator testing of 360 to 4000 revolutions per minute. Head adapters will increase speed ranges. Overspeeding up to 8000 rpm. regardless of range setting is claimed not to be damaging. Readings are guaranteed accurate to within ¼ percent of actual speed. The bridge circuit



principle is used. Other features are "permanent lubrication, no limited-life components and low-torque operation."

For further information write Metron Instrument Company, 432 Lincoln Street, Denver 9, Colo., referring to PETROLEUM REFINER *item* 306.

Storage Tank Roof (Item 307)

Chicago Bridge and Iron Company, in a new leaflet, describes the use of a "Vapordome" roof on a flat-bottom oil storage tank to prevent evaporation losses caused by daily breathing. A cutaway view of an oil storage tank with a Vapordome roof shows the flexible membrane in the dome at the center of the roof. The membrane moves up and down as vapor in the tank expands and contracts, due to temperature changes. This is claimed to prevent daily loss of vapor through the vents. A table of standard Vapordome roof sizes is also included.

For a copy of the leaflet write Chicago Bridge and Iron Company, 332 South Michigan Avenue, Chicago 4, referring to PETROLEUM REFINER *item* 307.

Mechanical-Drive Turbine (Item 308)

General Electric Company has developed a new standardized turbine, Type DR mechanical-drive turbine, for high speeds, wide speed ranges and "greater accuracy of control." Speed range is controlled by a position restored oil-relay governor providing adjustable speed ranges up to 5 to 1. "A steady state accuracy within ¼ of one percent is achieved" with ratings up to 1500 hp. available and speeds from 1000 to 8000 rpm. Parts are interchangable on all frame sizes of both DP and DR units.

For further information write General Electric Company, Schenectady 5, N. Y., referring to PETROLEUM REFINER *item* 308.

Tubing Clamp (Item 309)

Unistrut Products Company has developed a spring tubing clamp method for mounting or hanging tubing supports in any position. It is claimed that each tube may be fastened individually and while expansion and contraction are allowed the tubing is held in place. The clamps may be adjusted along the channel for changes in tube mounting position. The clamp will accomodate tubing from 3/16 to 1 inch outside diameter.

For further information write Unistrut Products Company, 1013 West Washing Boulevard, Chicago 7, referring to PETROLEUM REFINER *item* 309.

Expansion Joints (Item 310)

Prepared to give engineering and product information in industrial fields dealing with piping where pressure and temperature extremes exist and where pipeline expansion under working con-

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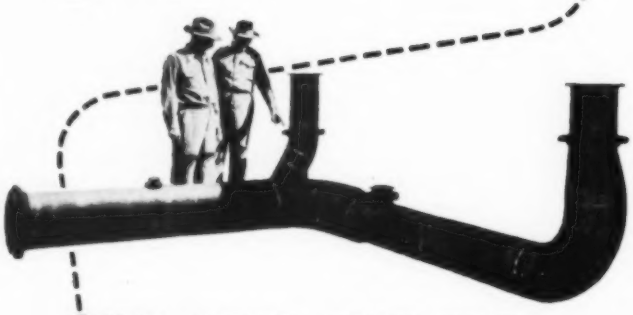
FOR
PETROLEUM-CHEMICAL PLANTS
BY Levingston



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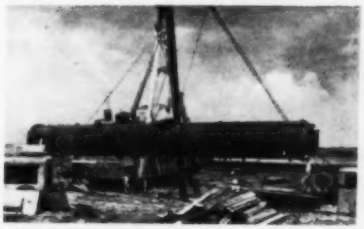

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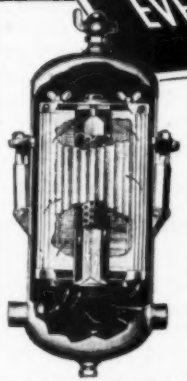

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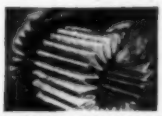

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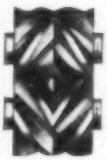
Kinney Heliquad Rotary Pumps are built to withstand *tough* pumping service. Throughout the petroleum industry, they have a reputation for stamina, dependability, and smooth-working performance. Don't overlook these advantages — specify KINNEY when superior pumping equipment is needed. Write for Bulletin L48 — address Kinney Manufacturing Company, 3596 Washington Street, Boston 30, Mass. Branches in New York, Chicago, Cleveland, Philadelphia, Los Angeles, San Francisco, Seattle.



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HARDENED STEEL TIMING GEARS drive the rotors; maintain close-limit clearances between rotors for lasting efficiency.

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Conservatively rated for the speeds and pressures of the service.

We also manufacture Vacuum Pumps, Clutches, and Bituminous Distributors.

KINNEY ROTARY PUMPS

New Equipment

ditions is important, Bulletin EJ-49 of Chicago Metal Hose Corporation covers corrugated type expansion joints in copper and stainless steel construction.

For a copy of this bulletin write on company letterhead to Chicago Metal Hose Corporation, Maywood, Ill., referring to PETROLEUM REFINER *item* 310.

Liquid Level Control (Item 311)

Suitable for use with a variety of liquids of .55 specific gravity and upwards, the new Type H liquid level control of Magneswitch, Inc., has, as key components of the assembly, Magneswitch units that are magnetic proximity switches containing Alnico permanent magnet elements. Internal pressure ranges from vacuum to 600 psi. and temperatures range to 700° F. Standard H control is supplied with 1¼ inch male connections on the side and bottom of the control body. The unit is not recommended for direct use with motors. Dimensions, specifications, wiring diagrams and information on switch ratings are contained in a bulletin.

For a copy write Magneswitch, Inc., 4840 South St. Louis Avenue, Chicago, referring to PETROLEUM REFINER *item* 311.

Corrosion Control (Item 312)

Methods employed by Owens-Corning Fiberglas Corporation to protect underground pipe lines from corrosion and the role of Fiberglas pipe wrap in corrosion control is described in a new company bulletin. Test data on the properties and performance of Fiberglas pipe wrap are included. Illustrations include charts and photographs.

For a copy of the bulletin write Owens-Corning Fiberglas Corporation, Toledo 1, Ohio, referring to PETROLEUM REFINER *item* 312.

Diesel Engines (Item 313)

Bulletin 4811 of The National Supply Company describes its Superior Dual Fuel diesel engines for gas or oil operation. Control is either with push buttons or hand lever. Three naturally aspirated models with power ratings of

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We weave 200 x 200 mesh in square weaves and 50 x 750 in Dutch Twilled. LEKTROMESH as fine as 400 x 400 is a standard item.

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We've had a lot of experience in making special holes for special purposes. Our Research and Service people just love tough problems. They will be delighted to help you, too, at any time. Write to Department 16.

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WIRE PRODUCTS Jelliff SINCE - 1860

175 hp. to 960 hp. and two turbo-supercharged models with ratings of 505 hp. to 1440 hp. are covered.

For a copy of the bulletin write Superior Engine Division, The National Supply Company, Springfield, Ohio, referring to PETROLEUM REFINER *item* 313.

Turbine Agitator (Item 314)

The new heavy duty "Mixco" turbine agitator, announced by Mixing Equipment Company, Inc., can be used on open or closed tanks, as a top or bottom entering unit, with direct or V-belt drive. It is claimed that the agitator can be standardized and adapted to various jobs. Details of the mixer drive which isolates shaft flexures from the gears, various impeller types and specifications of the complete unit are included in a company bulletin.

For a copy of the bulletin write Mixing Equipment Company, Inc., 1024 Garson Avenue, Rochester 9, N. Y., referring to PETROLEUM REFINER *item* 314.

Positive Gas Pumps (Item 315)

Advantage of the rotary positive gas pumps of Roots-Connersville Blower Corporation together with performance curves and similar data are presented in Bulletin 32-33-B-13. The four standard types of pumps are illustrated and line drawings showing iongitudinal section of each type are shown. The units cover a range from 2000 to 50,000 cubic feet per minute at pressures up to 15 pounds. Gears and bearings as well as the company's stuffing boxes are described and illustrated.

For a copy write Roots-Connersville Blower Corporation, 900 West Mount Street, Connersville, Ind., referring to PETROLEUM REFINER *item* 315.

Anodes, Backfill Material (Item 316)

Catalog Section M-8500A, published by National Carbon Company, Inc., describes ground anodes and backfill material for use in cathodic protection and electrical grounding. Tables are included for determining the type, size and quantity of ground anodes and the amount of backfill required. Type BF-2 graphite backfill material is also discussed.

For a copy of the catalog section write National Carbon Company, Inc., 30 East 42nd Street, Room 1328, New York 17, referring to PETROLEUM REFINER *item* 316.

Synthetic Organic Chemical (Item 317)

Physical and chemical properties, the uses and the chemical reactions of Monotert-Butyl-meta-Cresol, synthetic organic chemical offered by Koppers Company, are given in technical bulletin C-9-130. The chemical's phenol coefficient of 30-50 makes it useful as a germicide and a preservative for material attacked by bacteria and fungi. It also is used as an intermediate for the production of rubber chemicals and lubricating oil additives, etc. An infra-red spectrogram, commercial information on storage, handling and toxicity and a bibliography of references to technical and patent literature are also presented.

For a copy of the bulletin write Koppers Company, Inc., Pittsburgh 19, referring to PETROLEUM REFINER *item* 317.

There is nothing "Special" about
FILTER UNITS *fabricated by*
MULTI-METAL.

Special filter unit fabrications are routine production to Multi-Metal. More than 35 years of specialized handling of filter units in the processing industries go into every filter job constructed by Multi-Metal. All operations are handled right at our plant. This basket for example: a heavy mesh screen is shown being fitted to a sheet metal cylinder. It's typical of hundreds of other Multi-Metal jobs. Let us apply our special technique acquired over more than 35 years.

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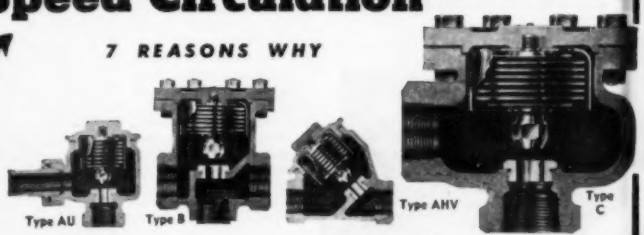
WIRE CLOTH COMPANY, INC. 1350 Garrison Ave., New York 59, N. Y.

Nicholson Steam Traps Speed Circulation

7 REASONS WHY



1. **BIG DISCHARGE, 2 to 6 times average traps.**
2. **NO AIR-BINDING. Discharge both air and water.**
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4. **NO DRIBBLING. Close tight when steam is in trap.**
5. **NO ADJUSTMENT needed for varying pressures.**
6. **NO WATER LOGGING. Operate on lowest temperature differential, 5° to 15°, depending on trap size and steam pressure.**
7. **LOWEST STEAM WASTE. As little as 1%.**

HIGH-PRESSURE FLOATS — Stainless, monel, steel or plated steel. Welded. In all sizes and shapes; for operating mechanisms and as tanks or vessels. 2-day delivery. **BULLETIN 348.**

5 TYPES for every application. Sizes ¼" to 2"; press. to 225 lbs. BULLETIN 1047.

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FOR ALGAE AND
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Operates on high vacuum — no moving parts. Only 6 ft. installation space. Sturdy cabinet permits outdoor installations. Available in 8 capacities — 15 lbs. to 2000 lbs. of chlorine per 24 hours. Ideal for chlorinating drinking water.

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WHEN THERE'S TROUBLE!
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A SUBSIDIARY OF PANELLIT, INC. MANUFACTURERS OF PREFABRICATED CONTROL SYSTEMS

About EQUIPMENT and SERVICE Suppliers

American Cyanamid Promotes Two in Chemical Division

The American Cyanamid Company has appointed C. F. Bonnet production manager of its industrial chemical division and G. W. Russell assistant sales manager of the same division.

Bonnet, who has been with Cyanamid for more than 15 years, formerly served as assistant general sales manager of the division. Russell, prior to his new appointment, had been manager of the new products development department. He is to take over the sales duties previously handled by Bonnet.

Bristol Names Akron Manager

J. H. Ferguson has been named district manager of the Akron, Ohio branch office of The Bristol Company. His headquarters are at 727 Grant Street, Akron 11. A graduate of Pennsylvania State College with a degree of bachelor of science in industrial engineering in 1921, he was associated with Western Electric Corporation before joining Bristol in 1923 as a sales engineer. Since 1940, Ferguson has been connected with the company's Washington, D. C. office.

Celanese Has Western Agents

Celanese Corporation of America has completed arrangements with three western firms to handle the distribution of its organic chemicals on the West Coast. Mefford Chemical Company, Los Angeles, will distribute Celanese chemicals for Southern California and Arizona. L. H. Butcher Company, San Francisco, and Carl F. Miller & Company, Seattle, will distribute chemicals in their respective territories.

Sun Distributor Named

L. C. Black, 2906 Cherry Avenue, Long Beach 6, Calif., has been assigned California distributor for Sun Engineering Company, Oklahoma City.

Dresser Industries Hold Open House

Dresser Industries, Inc., last month opened new division offices and a service depot at 1619 Ovid Street, Houston, where an open house attracted 600 guests and brought Dresser officials from all parts of the country. In addition to air-conditioned office space containing 6000 square feet, the setup includes 14,000 square feet of warehouse facilities. These new facilities will serve as Gulf Coast headquarters for Dresser Industries, Inc., and its oil and gas equipment manufacturing subsidiaries including Clark Bros. Company, Inc., and Pacific Pumps, Inc. All of Texas (except the Panhandle), Louisiana, Mississippi, Alabama and parts of Southern Oklahoma and New Mexico will be served from this point. Under supervision of Fred H. Hayes, division manager, Clark Bros. will maintain at Houston a complete service and parts department with a full staff of service engineers. Pacific Pumps from these quarters will service all of Louisiana and Texas south of Wichita Falls, although Wendell R. Carlsen, Houston division manager for Pacific's centrifugal pump division, said his company would not maintain warehouse facilities or stock centrifugal pumps or parts at the new Houston address, this serving mainly as a Gulf Coast office only. Included among the officials attending were C. P. Clark, president, David K. Hutchcraft, vice president and director of sales and Francis W. Laverty, general sales manager, all of Clark Bros. Company, Inc., and Richard Porter Brown, director of personnel and organization planning, Dresser Industries, Inc., Cleveland.

Shown in the accompanying picture are, left to right, standing: J. C. Brown, export sales, Security Engineering Company, Inc.; Fred H. Hayes, of Clark Bros.; Louis R. Spencer, district manager, Ideco stores division, International Derrick & Equipment Company; and C. A. Buckner, district manager, Kobe, Inc. Kneeling: John W. Stewart, Gulf Coast manager, Security Engineering Company, Inc., and Wendell R. Carlsen, Houston division manager, Pacific Pumps, Inc.

Berman

Taylor

Bethlehem Supply Advances Three in Sales Department

New manager of refinery sales for Bethlehem Supply Company is W. F. Taylor. He succeeds T. B. Leech, who is resigning to join Petro-Chem Development Company. Before coming to Bethlehem in 1936, Taylor was employed by Indian Territory Illuminating Oil Company for ten years. For several years he has been sales representative at Bartlesville, Okla.; Omaha, Neb.; Kansas City, Kan.; and Chicago.

Myers

Bethlehem has transferred R. M. Berman to Tulsa to handle the sale of Petro-Chem iso-flow heaters, super heater and boilers. He received his bachelor of science degree in chmical engineering at the University of Texas in 1938, and then joined Hercules Powder Company. He came to Bethlehem in 1948.

Succeeding Taylor is Luther A. Myers. He served several years with Murray Brooks, Inc., and was sales manager with the company when he joined the Air Corps in 1942. His headquarters are at Tulsa.

Swan to South America As Dowell Representative

Lester B. Swan, Dowell Incorporated district manager at New Orleans, has been named general manager of United Oilwell Service, S. A., in Caracas, Venezuela. United Oilwell is an associate company of Dowell. Formerly with Stanolind Oil & Gas Company, he is a graduate petroleum engineer from the University of Tulsa.

Charles L. Power, Jr., district development engineer in Lafayette, La., succeeds Swan at New Orleans. With Dowell since 1936, he attended Southwestern College in Memphis, Tenn.

William Keeley Becomes U. S. Chemical Executive

William C. Keeley has assumed duties as executive vice president of U. S. Industrial Chemicals, Inc. A vice president of Air Reduction Company, Inc. from 1936 to 1948, he served as chairman of its finance committee during the past year.

A graduate of Sheffield Scientific School, Yale University, Keeley during World War II was vice chairman of the War Production Board for metals and minerals.

G-R Makes Executive Changes; Ris Elected to Presidency

Kenneth B. Ris has been elected president of The Griscom-Russell Company, succeeding Russell C. Jones, who is retiring as president but will continue as a director. At the same time, Charles D. Steffens, former sales manager, was elected vice president of sales, Ris's former position. Vice president of petroleum sales is James W. Elizardi.

Employed by Griscom-Russell in 1922, Ris served in the New York engineering department and the Chicago, New York, Tulsa and Dallas sales offices before becoming manager of the petroleum sales division in 1931 and sales manager in 1934. With the company since 1926, Steffens specialized in sales to utilities in Chicago and New York before being made sales manager in 1946. Elizardi came to Griscom in 1928 and has since specialized in petroleum sales.

Cochrane Acquires Subsidiary

Cochrane Corporation, Philadelphia, has acquired most of the capital stock of Liquid Conditioning Corporation, Linden, N. J. Liquid Conditioning will operate as a wholly owned subsidiary of Cochrane, but its products will continue to be marketed under the trade name, "Liquon."

S. B. Applebaum, organizer and officer of Liquid Conditioning, will be in charge of the cold water conditioning activities as well as the conditioning of other liquids for both organizations. Engineering, sales and technical staffs of the two corporations will augment each other.

Oil Tool Opens New Store

Oil Tool Manufacturing Company, Houston, next month will open a new store distribution point in Odessa, Texas, which "will provide over-night service on oil field and industrial piping supplies

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EASILY APPLIED WITH SPRAY OR BRUSH, DRIES QUICKLY

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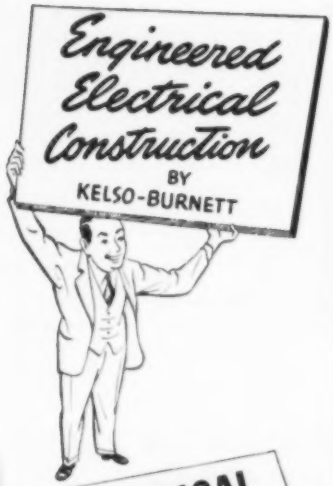

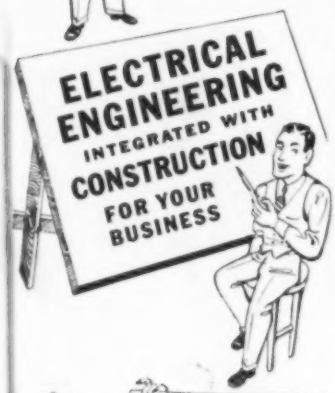

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K·B SERVING INDUSTRY SINCE 1908

CHICAGO 6, ILLINOIS

to the West Texas, southern Oklahoma, New Mexico and Colorado areas."

J. Koetter, sales manager for Oil Tool, visited the Odessa area in early May to complete arrangements for the opening.

Sardieck

Layritz

Lunkenheimer Company Names Sales Manager and Assistant

The Lunkenheimer Company has named Harold H. Layritz sales manager and Roland J. Sardieck assistant sales manager.

In 1920 Layritz joined Lunkenheimer. He worked in the factories, general offices and sales division before being appointed assistant sales manager. A graduate of the University of Cincinnati, he served as national secretary of Triangle fraternity for several years.

Sardieck served in various capacities after coming to Lunkenheimer in 1918. Then he was transferred to the Philadelphia branch office as assistant manager, later becoming branch manager. He is returning to Cincinnati to take Layritz' former post.

American Structural Assigns Arthur Pike to New England

Arthur B. Pike has been assigned to the New England territory as Kaylo insulation sales engineer for American Structural Products Company, a subsidiary of Owens-Illinois Glass Company. His headquarters are at 1227 Statler Office Building, 20 Providence Street, Boston 16. His territory includes Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and part of Connecticut.

Pike

Previously Pike has been a manufacturer's agent in the Boston area for industrial equipment and allied products. He is a graduate of the University of New Hampshire, receiving his bachelor of science degree in chemistry in 1934.

Kieley & Mueller Names Agents

Kieley & Mueller, Inc., has named Van Hala Industrial Sales Company, 1051 Power Avenue, Cleveland 14, Ohio, as exclusive sales representative in the Cleveland area. Henry A. Van Hala, head of the distributor organization, was formerly Cleveland district manager for the Bristol Company.

John G. Kirkpatrick, 4405 Schenley Farms Terrace, Pittsburgh 13, has been appointed exclusive sales representative in the tri-state area of Pennsylvania,

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175	325	700	1300
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200	350	800	1400
213	363	850	1450
225	375	900	1500
238	388	950	1550
250	400	1000	1600
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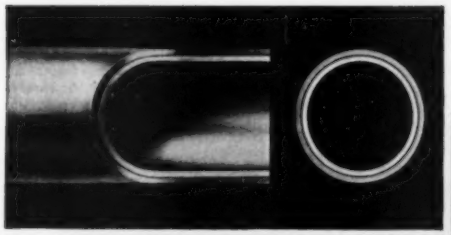
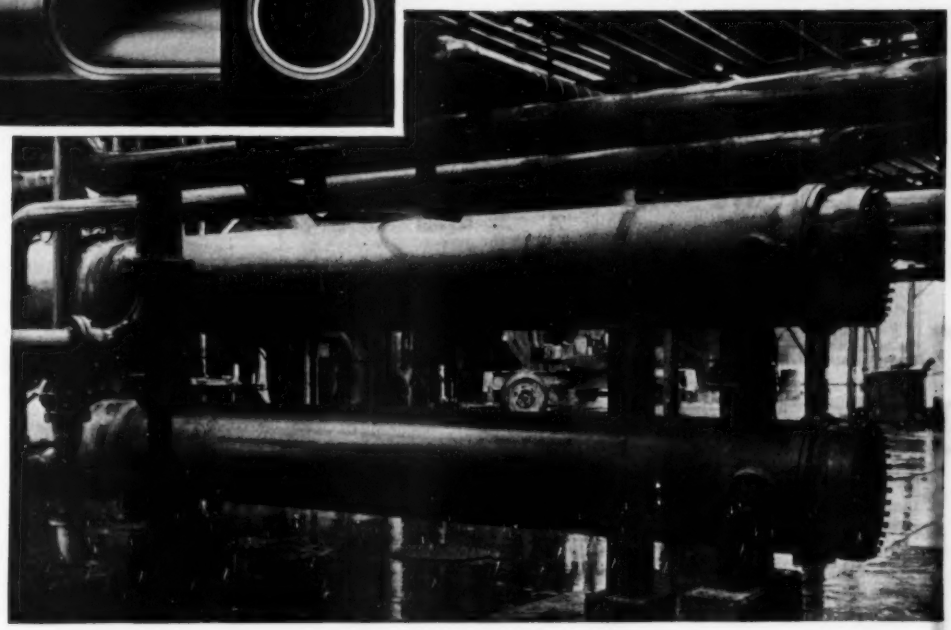


Anaconda Duplex Tubes are manufactured to meet special needs . . . formed usually with seamless copper alloy tube drawn either inside or outside of seamless steel tube.



ANACONDA DUPLEX TUBES resist water-side corrosion at Lake Charles operations of Mathieson Chemical

DUPLEX HEAT EXCHANGER TUBES . . . steel, lined with Anaconda Arsenical Admiralty 439 . . . are successfully withstanding the attack of corrosive river water in the Lake Charles, La. plant of the Mathieson Chemical Corporation.

These tubes are employed in two heat exchangers recently built by the Alco Products Division, American Locomotive Company at their Beaumont, Texas plant, to handle 134,000 lb. per hr. of ammoniacal copper acetate on the shell side and 212,000 lb. of river water per hr. through the tubes.

Anaconda Duplex Tubes are special purpose tubes, designed to meet specific requirements, but are available in a wide range of sizes, gages and alloys. The nonferrous tube may be drawn either inside or outside of the steel tube, or Duplex Tubes may be fabricated from two different nonferrous alloys.

Our Technical Department, with its wide experience in solving many kinds of tube problems and its extensive laboratory facilities, is at your service at all times. For further information, write for Publication B-2.

ANACONDA

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THE AMERICAN BRASS COMPANY

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Marketing Executive

Major oil company has opening for executive who can initiate and develop sales distribution of natural gasoline and liquefied petroleum gas. Good salary and fine opportunity for right man.

Chemical engineering background desirable. Must be thoroughly experienced in marketing of these products.

All replies will be kept confidential. Furnish complete particulars in letter of application.

Address: Box 147-R, c/o Petroleum Refiner, Houston, Texas.

Wanted:

Welding and Boilermaker Foreman—Must have experience in these trades and in supervising. Oil refinery experience preferred. Write, giving training, experience, references and personal details to: Carter Oil Company, P. O. Box 2094, Billings, Montana.

PIPING SUPERINTENDENT

Construction firm has opening in California for an experienced Piping Supt. Minimum 5 years experience on lump sum contracts. Furnish experience record and photo. Address: Box 150-R, c/o Petroleum Refiner, Houston, Texas.

Wanted:

Purchasing Agent—Familiarity with refinery equipment and specifications. Write, giving training, experience, references and personal details to: Carter Oil Company, P. O. Box 2094, Billings, Montana.

Wanted:

Materials Engineer—Experience in listing, expediting, and storehouse control of material, with oil refinery maintenance or construction background. Write, giving training, experience, references and personal details to: Carter Oil Company, P. O. Box 2094, Billings, Montana.

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Chemical Engineer, age 35, M.S. in Ch. E., congenial, ambitious, energetic, Texas registered professional engineer. Varied experience including chemist, research engineer, design and construction engineer, plant superintendent of large and small plants, independent pipeline contractor. Desires high type sales or administrative position. Position should be such as to yield a great deal of personal satisfaction as well as considerably above average income. Now located East Texas. Available immediately. Address: Box 146-R, c/o Petroleum Refiner, Houston, Texas.

Established reliable industrial plant Engineering and Construction firm in Houston, Texas, wishes to license the engineering and/or construction processes in the Chemical, Petro Chemical or Petroleum industry in the Gulf Coast and Southwest industrial areas. Address: Box 149-R, c/o Petroleum Refiner, Houston, Texas.

Asphalt Executive

Large oil company not now in road and industrial asphalt business, desires executive capable of developing this field from standpoint of manufacturing, research, and sales operations. Unusual opportunity, with good salary and other benefits.

Besides sales engineering ability, this executive must be familiar with the chemistry of asphalt, and know specifications and manufacturing techniques of the product.

All replies in strict confidence. Give full information with application.

Address: Box 147-R, c/o Petroleum Refiner, Houston, Texas.

New Jersey and New York. For four years he was sales engineer for The Bristol Company. He then spent a year with Fischer & Porter Company and seven years with Koppers Company, Inc., in the instrument and engineering departments.

GE Promotes James Goss

James H. Goss has been promoted to manager of engineering in the control divisions of the apparatus department of General Electric Company. He entered General Electric as a student engineer in 1931, following his graduation from the University of Arkansas in 1930 with a bachelor of science degree in mechanical engineering. In 1936 he was named engineer of the works laboratory at West Lynn, Mass., and in 1946 was made assistant to the works engineer. Appointed assistant division engineer in 1947, Goss was promoted to assistant manager of engineering late the same year.

Mixing Equipment Appoints Two Field Representatives

Roney Johnson II, Clearwater, Fla., and Industrial Sales & Engineering Company, Buffalo, N. Y., have been appointed field representatives by Mixing Equipment Company, Inc., Rochester, N. Y.

Johnson

Johnson has served as engineer with Midvale Steel Works, RCA Manufacturing Company, General Steel Castings Corporation, General Electric Company, E. I. Du Pont de Nemours Company, Hercules Powder Company, Fraser Brace Engineering Company and La Bour Company.

Industrial Sales is headed by Roy A. Bass. Holding a master of engineering degree from Cornell University, he was formerly employed by Ross Heater & Manufacturing Company and Dresser Industries, Inc. Kenneth C. Bass, his partner, is a graduate mechanical engineer from the University of Kentucky. He has been associated with Durez Plastics & Chemicals, Inc., Remington-Rand Company and Ross Heater.

James L. Crawford Promoted To Presidency of Walsh

James L. Crawford has been elected president of Walsh Refractories Corporation. Former vice president and general manager, he succeeds N. S. C. Walsh, retiring president, who was named honorary board chairman. The company recently moved into its new offices at 101 Ferry Street, St. Louis 7.

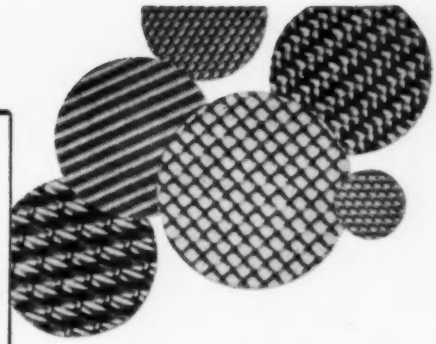
Crawford

Following his graduation in 1917 from the University of Illinois with a degree in ceramic engineering, Crawford was employed by Westinghouse Lamp Company. From 1919 to 1932 he was a fellow in the Mellon Institute and engaged in research in the field of fire clay refractories. He was associated with Laclede-Christy Company from 1923 to 1932. In 1932 he joined Walsh as general manager, later becoming vice president and general manager and a member of the board of directors. He also is a director of Mississippi Glass Company.

J. Lawrence Kennedy Promoted

J. Lawrence Kennedy has been announced as assistant to the president of The Kennedy Valve Manufacturing Company. He will also direct the company's advertising and sales promotion activities. For ten years he was associated with Charles L. Rumrill & Company, Inc., advertising agency, resigning from the company as first vice president. During the war he was an instructor in the Air Corp.

Compare this *Screen* and *Filter Cloth* with any you are now using!



FILTER and screen elements need not be weak spots in your equipment.

And they won't . . . if they're made of Monel*, Nickel or Inconel* wire cloth.

For these are the "task metals" of industry.

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Nickel
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"Task Metals" for Industry

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Building steel plate fabricated equipment is only part of our job. Transporting that equipment to the customer's site often involves ingenious planning and meticulous attention to the details of loading.

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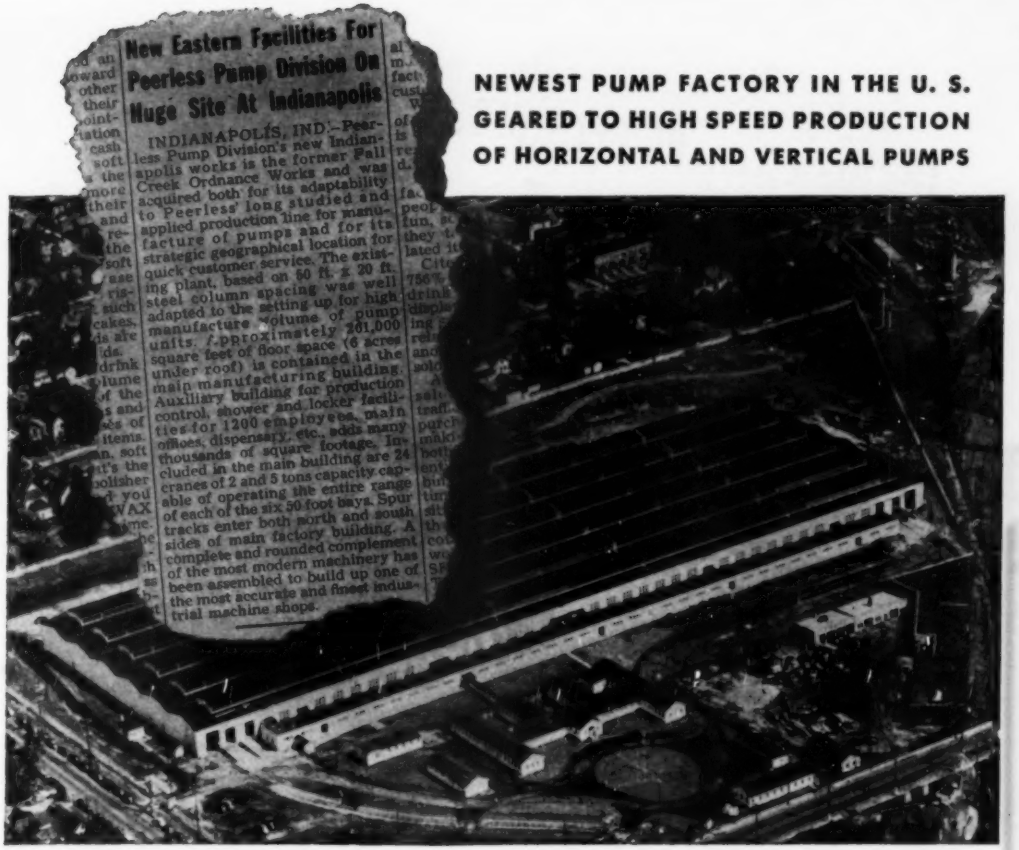
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Huge Site At Indianapolis
INDIANAPOLIS, IND.—Peerless Pump Division's new Indianapolis works is the former Fall Creek Ordnance Works and was acquired both for its adaptability to Peerless' long studied and applied production line for manufacture of pumps and for its strategic geographical location for quick customer service. The existing plant, based on 50 ft. x 20 ft. steel column spacing was well adapted to the setting up for high manufacture volume of pump units. Approximately 201,000 square feet of floor space (6 acres under roof) is contained in the main manufacturing building. Auxiliary building for production control, shower and locker facilities for 1200 employees, main offices, dispensary, etc., adds many thousands of square footage. Included in the main building are 24 cranes of 2 and 5 tons capacity capable of operating the entire range of each of the six 50-foot bays. Spur tracks enter both north and south sides of main factory building. A complete and rounded complement of the most modern machinery has been assembled to build up one of the most accurate and finest industrial machine shops.

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OF HORIZONTAL AND VERTICAL PUMPS**

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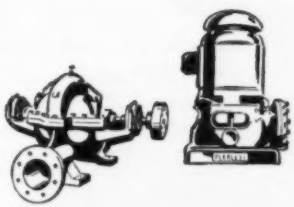
Here is one of America's most modern pump factories. Peerless Pump's new plant at Indianapolis is devoted entirely to making pumps and handling pump service. All types of pumps in the Peerless line, horizontal centrifugal, deep well and close-coupled turbines, Underwriters' approved fire pumps and domestic water systems are made and serviced in this plant. No expense has been spared in tooling Peerless-Indianapolis to insure accurate pump production; testing facilities at Indianapolis are being incorporated into one of the largest pump laboratories in the country. Add these factors to sound basic Peerless pump designs, to the high caliber of Peerless personnel and to Peerless extensive manufacturing facilities at Los Angeles, California, and they combine to make available as comprehensive pump service as is offered to pump owners and buyers anywhere. Peerless-Indianapolis is open for your inspection. You are cordially invited to see for yourself how Peerless-Indianapolis will exactly fit your needs for pumps and pump service. Plan with Peerless; there are horizontal and vertical types for most services, in all industries. Descriptive Bulletins are available on all types upon request.



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FOOD MACHINERY AND CHEMICAL CORPORATION
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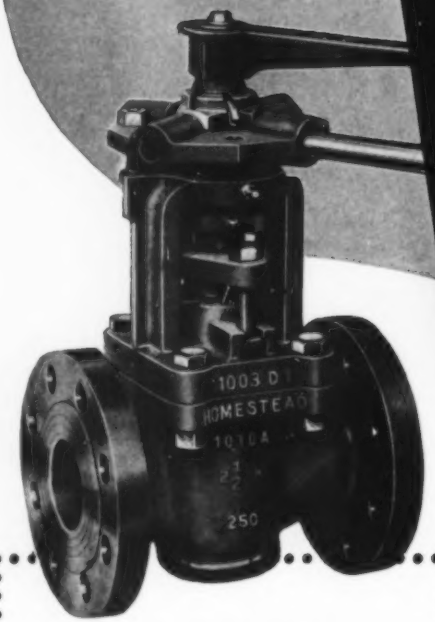

- Instant Stick-Proof operation.
- Quarter-turn fully opens or closes.
- Positive seal without lubrication.
- Seating surfaces always protected in both open and closed positions. Corrosion practically eliminated.
- Unobstructed straight-line fluid flow.
- All operating parts protected from damaging effects of service conditions and weather.

For 16 years, they have been first choice for difficult services where extremes of temperature or pressure or corrosive line fluids cause ordinary valves to "stick" or "seize." Due to their exclusive "Lever-Seald" construction, they render instant, Stick-Proof service. They operate fast, too . . . full open or close in a quarter-turn . . . 16 to 28 times faster than screw-stem-type valves. And because all operating parts are protected from the damaging effects of line fluids, service conditions and weather, long life, low maintenance and trouble-free service are assured.

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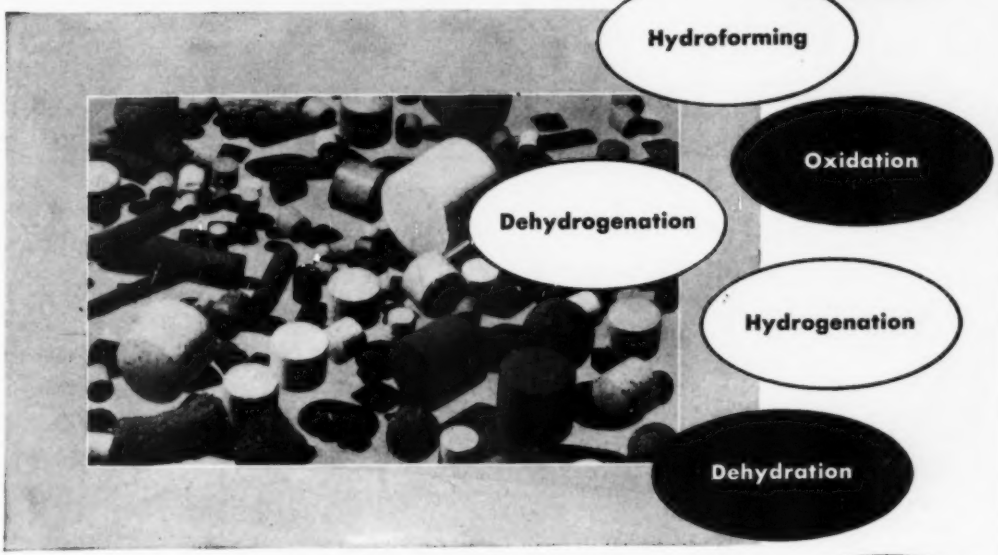

There is an ever-increasing demand for Harshaw preformed catalysts and catalytic chemicals. Newly developed processes use and find Harshaw catalytic materials extremely dependable. Harshaw not only has a wide practical knowledge of how preformed catalysts and catalytic chemicals are used but also has a large capacity for their manufacture . . . to your specifications if you wish. We will be glad to discuss your catalyst problem with you.

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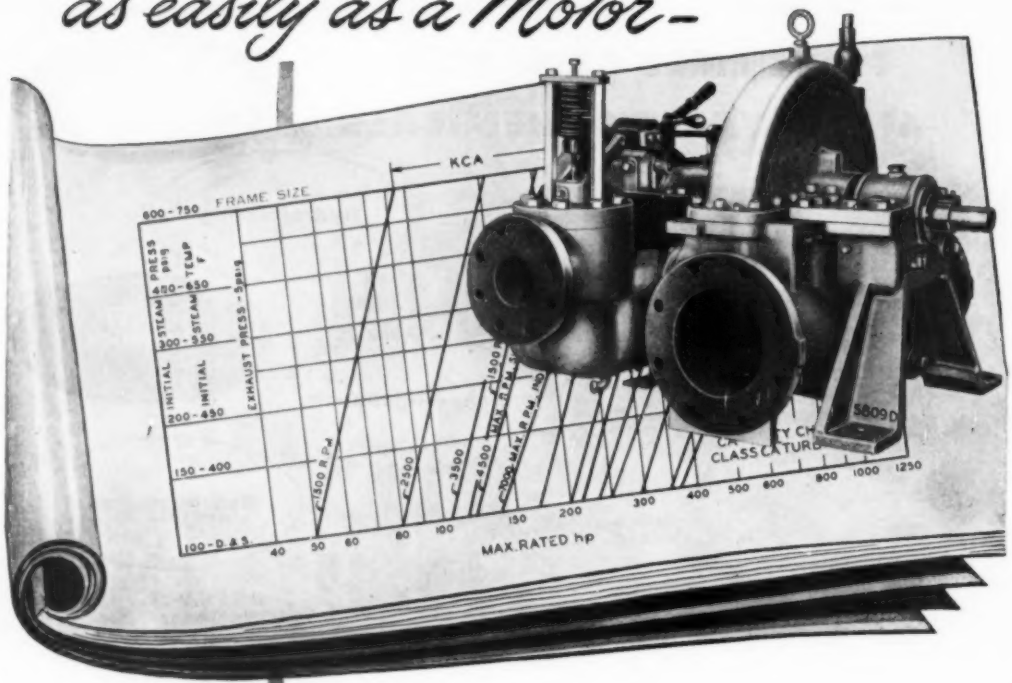
as easily as a Motor–



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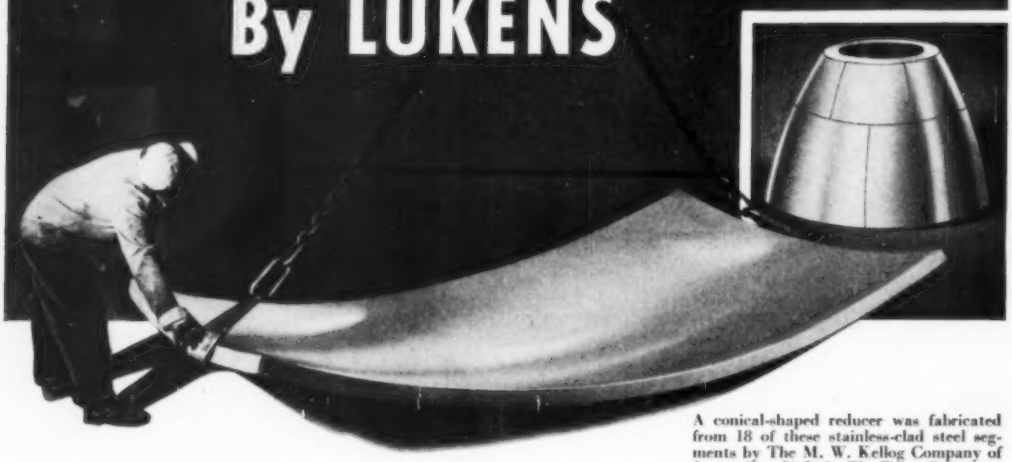
STAINLESS-CLAD STEEL
By LUKENS



A conical-shaped reducer was fabricated from 18 of these stainless-clad steel segments by The M. W. Kellog Company of Jersey City, N. J., for The Texas Company.

HOT PRESSED by By-Products Steel Co.

Lukens Stainless-Clad Steel plate, nearly three inches thick, was flame-cut into segments, hot pressed and then welded into the conical shape shown here. Its corrosion-resistant surface of stainless steel remained intact.

All Lukens Clad Steels—Nickel-Clad, Stainless-Clad, Inconel-Clad and Monel-Clad—have the same permanence of bond and uniformity of cladding. Use them in your equipment and gain the advantages of these *solid* corrosion-resistant metals with the economies of *clad* steels. Lukens makes plate as wide as 178 inches or to over 3 inches thick. All are available in the extra-smooth sodium hydride finish.

By-Products Steel Co., Division of Lukens, offers you all kinds of metal forming services such as flame-cutting, shearing, pressing, blanking, bending and forming. Bulletin 270 describes these facilities.

For a copy, and for Bulletins 255 and 338 on Lukens Clad Steels, write Lukens Steel Company, 404 Lukens Building, Coatesville, Pennsylvania.

CLAD METAL STEEL

LUKENS

Nickel-Clad Stainless-Clad
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STEELS

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- **CAST STEEL** Flanged End Gate Valves, Forged Steel Globe Valves, Gate and Check Valves.
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- **NATIONAL** Seamless Steel Pressure Tubing, Seamless Steel Heat Exchanger and Condenser Tubes.
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New Design Feature
CHAPMAN VALVE
List 960

Gives more than 50% increase in strength of stem and wedge gate connection...meets the most extreme operating conditions.

Valve stems and gates with the new scientifically designed connection are interchangeable with all List 960 Valves now in service

Here's one more result of the year after year program of research which Chapman carries on to make the List 960 *tops for toughness.* Reason why this small gate valve can lower your maintenance cost — give you more years of useful valve life.

Consistently you will find the Chapman List 960 is *your best valve buy.* It is available in sizes $\frac{1}{4}$" to 2" . . . rising stem with yoke (as illustrated). Also available rising stem inside screw type. For pressure range 2000 lb. at 100 deg. F., 380 lb. at 1000 deg. F.

For higher pressures specify List 990.

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And don't forget the wear resisting and non-galling properties of the hard heat treated seat rings and the 800 Brinell hardening of the wedge faces by the exclusive Malcomizing Process.

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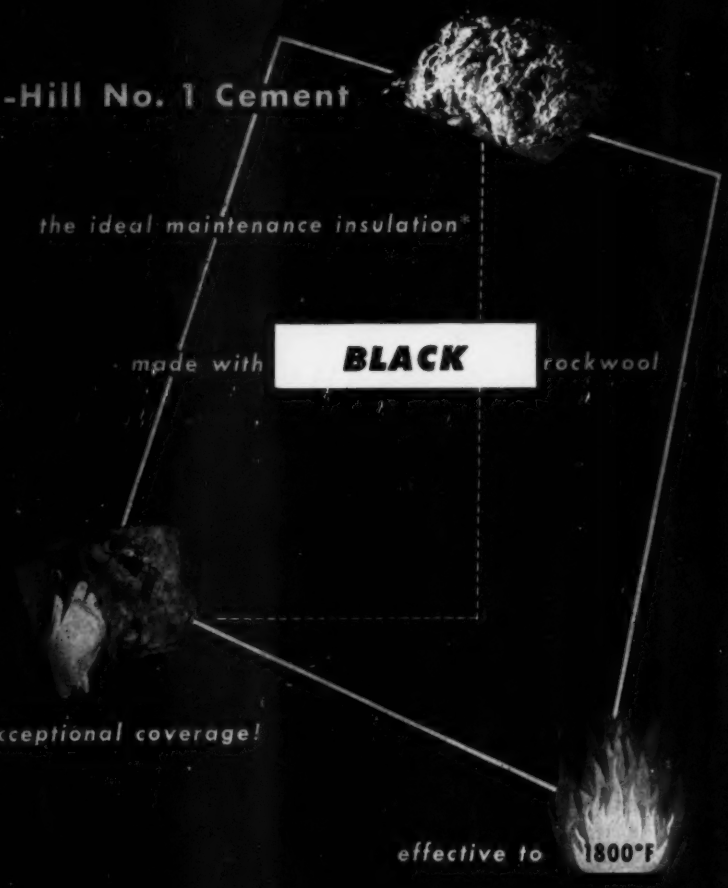
Baldwin-Hill No. 1 Cement

*the ideal maintenance insulation**

made with **BLACK** *rockwool*



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**rust-resistant!*

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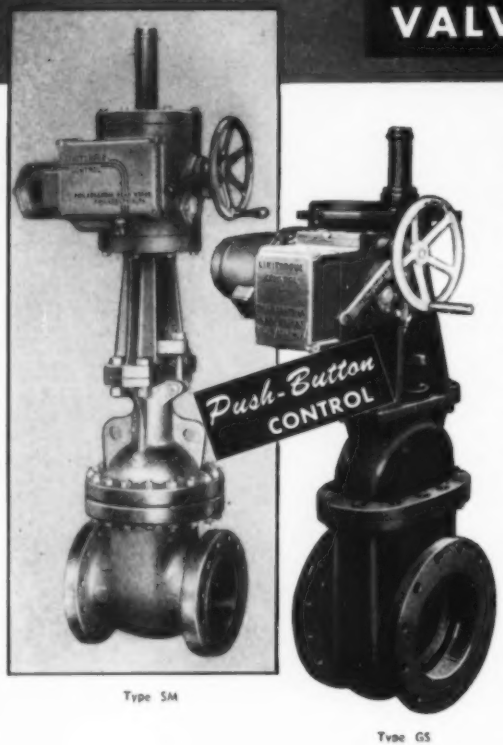

Type SM

Type GS

LimiTorque is a sensitive, automatic, mechanically actuated device for opening and closing globe, gate, penstock and rotary plug valves; sluice gates; garage, factory and hangar doors; induced and forced damper controls; sprinkler systems; feeder dis-connect switches; watertight bulkhead doors, etc. Most valves are damaged by improper seating, or by meeting some obstruction in closing . . . *LimiTorque control* gives absolute assurance against improper seating, by means of a *positive safety* overload mechanical torque cut-out. If obstruction is met in closing valve, the torque switch becomes operative, and dis-connects the motive power—thus preventing broken gates or discs and damaged stems. Philadelphia *LimiTorque* is the *only* automatic valve operating device that employs this positive principle of operation and control.

LimiTorque, with all its remarkable sensitiveness, is a simple piece of mechanism, containing as few parts as possible. No de-clutching coils are necessary . . . if the current is available at the motor terminal, *LimiTorque* will function regardless of whether valve was last operated manually or electrically.

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LimiTorque Controls are designed by engineers who were directly associated with the development of the original mechanical valve operators.

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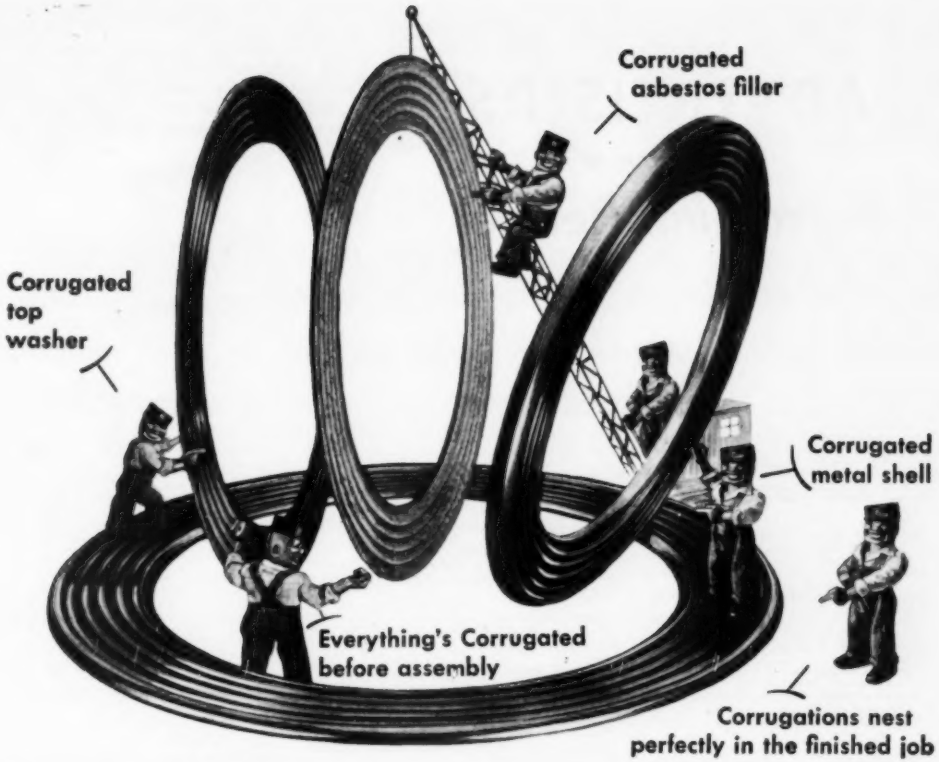
Industrial Gears and Speed Reducers
LimiTorque Valve Controls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Corrugated top washer
Corrugated metal shell
Everything's Corrugated before assembly
Corrugations nest perfectly in the finished job

Greater Strength... More Resilience... Perfect Sealing!

...with this corrugated metal-asbestos gasket

IN THE FABRICATION of the Goetze Style 926 metal-asbestos gasket shown here, each of the three units is corrugated *individually* to assure perfect "nesting" and matching in the assembled gasket.

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Goetze custom-made gaskets—such as Style 926 above—pay off in the long run because of the meticulous care that is taken with every detail of construction . . . care and skill that is based on more than sixty years of meeting the specialized gasket requirements of industry.

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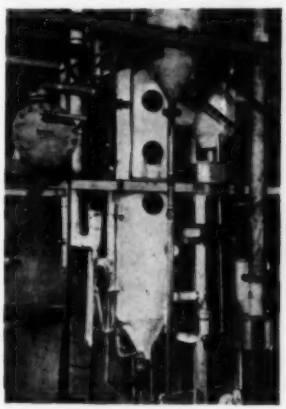
Recently the John Nooter Boiler Works Co. in St. Louis . . . well-known precision fabrication specialists . . . completed the two tough jobs shown here for the chemical industry.

A calandria and six reactors, this is typical chemical equipment that demands the best in basic metals and fabrication methods . . . reliability with low maintenance cost.

Which is why two Revere copper alloys were specified . . . because Revere products and service are the soundest starting point for any manufacturer using copper and its alloys.

A Famous Chemical Manufacturer Uses Six of These Reactors As a Vital Part of Production.

Here again Revere has supplied the correct alloy for a difficult job. Revere's Cupro-Nickel 70-30 is the copper-base alloy most resistant to salt water corrosion. With its great resistance to failure by stress-corrosion and corrosion-fatigue, it is used when conditions are unusually severe. 70-30 Cupro-Nickel has high strength, high ductility . . . can be stamped, cold forged, drawn and bent. It is used for condensers, heat exchangers, and process equipment.



Washington University in St. Louis Ordered This Calandria for Research Work in Their Chemical Engineering Laboratory.

Revere's famous silicon-bronze alloy HERCULOY *supplies the necessary tensile strength and resistance to corrosion this combination still and heat exchanger requires.* HERCULOY *cold-works and hot-works readily, is easily welded by any of the commercial methods, has superior fatigue resistance, is used in operations requiring resistance to alternating and cyclic stresses. It has the corrosion resistance of copper plus the strength of mild steel.*

As the chemical industry is doing, more and more industries needing copper and copper-base alloys are turning to Revere for the best in service and guidance. Before placing your next order for copper or copper alloys, call your nearest Revere office. The Revere Technical Advisory Service will gladly collaborate with you.

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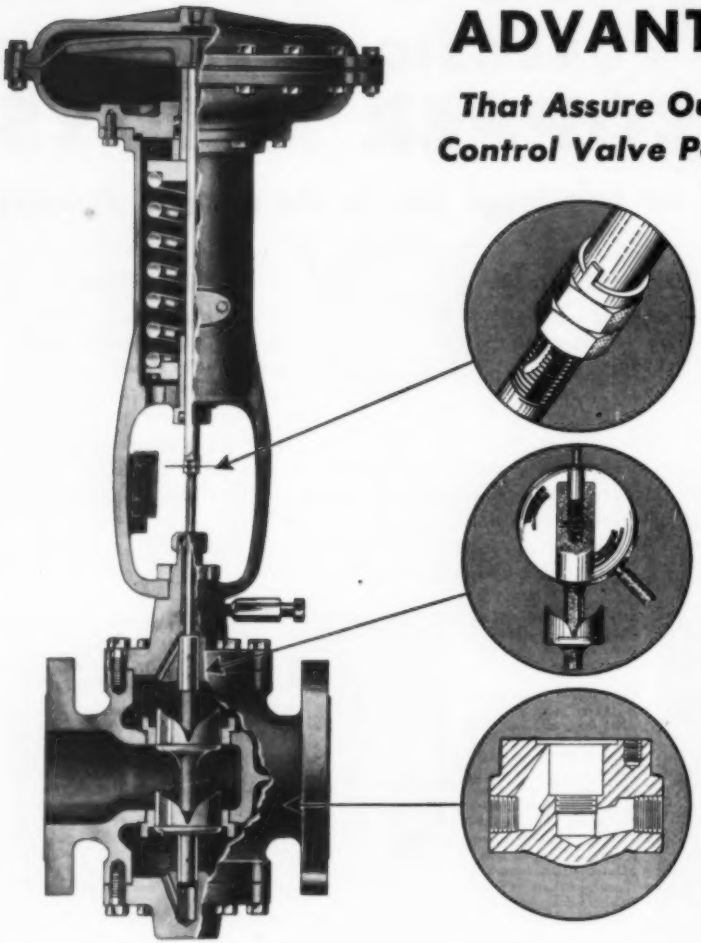
THREE MASONEILAN ADVANTAGES

That Assure Outstanding Control Valve Performance



1 Positive Lock Between Plug Stem and Spring Stem — With the Masoneilan Plug-Spring Stem Key Lock, torsional strain is entirely removed from the locknuts and placed on two lugs of the locking plate. Four milled slots in the spring stem and receive two equally spaced lugs on the locking plate. A keyway in the plug stem engages one lug on the locking plate to complete the lock. Actual tests prove this assembly withstands torsional stress to the point of stem failure.

2 Pinning Plug and Plug Stem Assures Strongest Possible Assembly — The Masoneilan Threaded and Pinned Stem and Plug Construction does away with toggles and free alignment joints. The plug guide is drilled and tapped with a pilot section above the threads for accurate centering of the stem. The threaded joint provides mechanical strength. The stem is locked into the plug by a special grooved pin which fits tightly at both ends in the guide as well as in the center through the stem.

3 Forged Steel Globe Type Valve Body — The Forged Steel in the body of the valve provides a dense homogeneous grain structure and eliminates porosity. This design permits an increase in size of body ports. It permits the maintenance of flow characteristics throughout the range of flow and reduces flow disturbance.

Illustrated above are but 3 of the many Mason-Neilan developments which assure maximum performance and dependability in Masoneilan Control Valves. In addition, diaphragms are correctly sized to have ample effective area to provide sufficient force to positively position the valve. Springs are carefully calibrated for each type and size of valve. New Yoke assembly assures sturdier construction.

It will pay you to investigate Masoneilan Control Valves for your applications.

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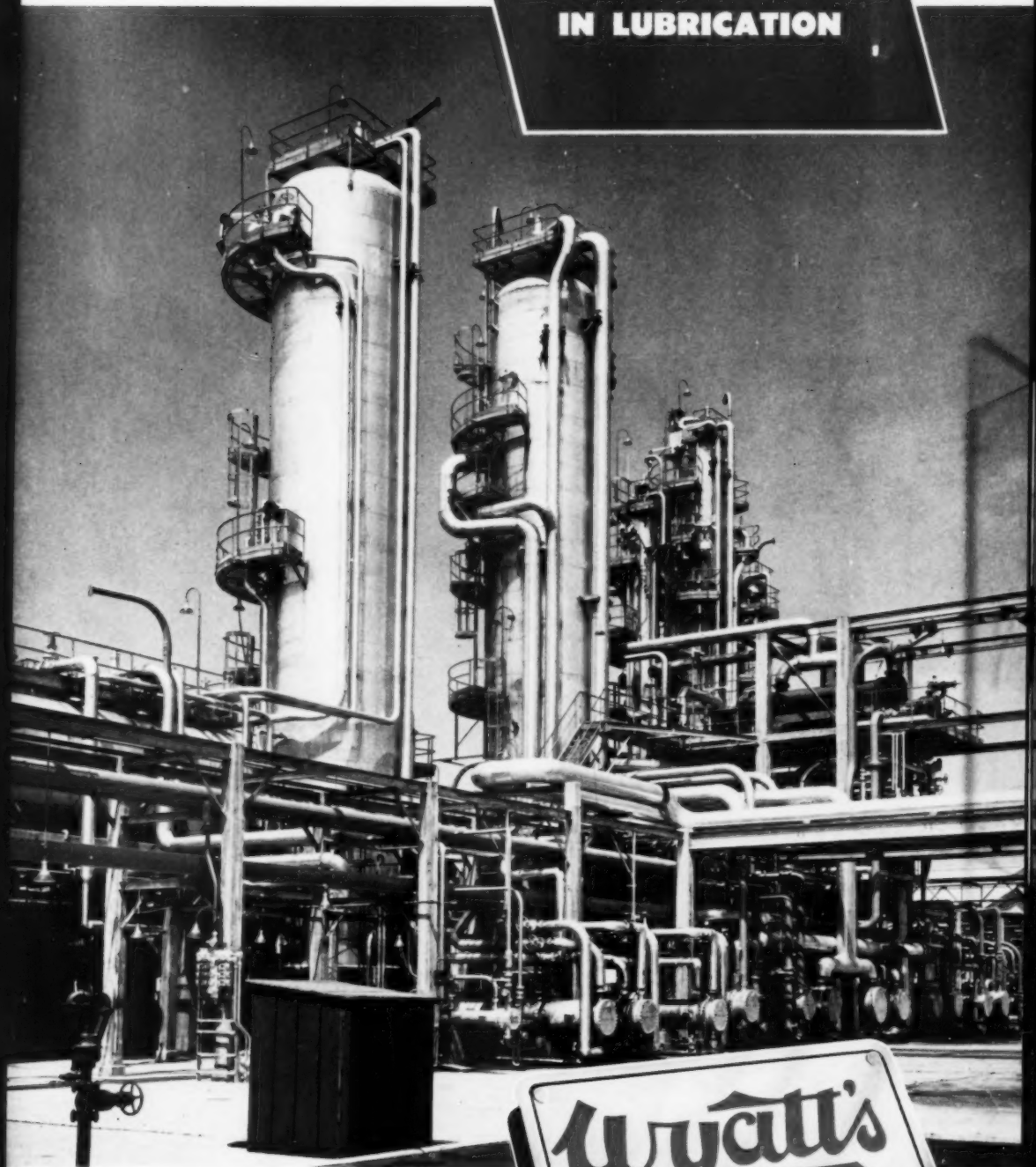
Mason-Neilan Regulator Co., Ltd., Montreal and Toronto

STUDY OF PROGRESS IN LUBRICATION



Phenol extraction unit in lube oil plant on the Gulf Coast . . . a picture of modern fabricating by Wyatt Metal & Boiler Works for a major engineering construction company.

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PLATE 832-A

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PLATE 832-H

1" suction ¾" discharge—for mounting on the 2" pipe column of underground tanks. Furnished with hose nozzle, vacuum breaker and 1" foot valve. (Pedestal and suction pipe not supplied.)

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